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Practical Sequential Design Procedures for Submarine ASW Search Operational Testing: A Simulation Study

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October 1998

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IDA Document D-2060

Log: H 97-002281

19981229 026

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INSTITUTE FOR DEFENSE ANALYSES

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**Practical Sequential Design Procedures
for Submarine ASW Search
Operational Testing: A Simulation Study**

Steve Warner

PREFACE

This document was prepared by the Institute for Defense Analyses (IDA) for the Director, Operational Test and Evaluation, in partial response to the task "Support for DOT&E in the Assessment of Submarine Warfare Systems." In the spring of 1997, IDA presented an overview briefing on the use and value of sequential test control rules in anti-submarine warfare (ASW) search operational testing to DOT&E and to the Commander, Operational Test and Evaluation Force (COMOPTEVFOR). The objective of this effort is to document the technical analyses that supported that briefing.

The IDA Technical Review Committee was chaired by Mr. Thomas P. Christie and consisted of Mr. Jeffrey R. Ball, Dr. Merlin G. Bell, Mr. Dean D. DeWolfe, Dr. Arthur Fries, ADM Lawrence Layman (Ret.), and Dr. Joseph L. Lockett.

The author would like to thank Dr. Jerome C. Rosenberger for his comments and critiques throughout this effort.

PRACTICAL SEQUENTIAL DESIGN PROCEDURES FOR SUBMARINE ASW SEARCH OPERATIONAL TESTING: A SIMULATION STUDY

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SUMMARY

The efficient design of a free-play, 24-hour-per-day, operational test (OT) of an ASW search system remains a challenge to the OT community. It will often be the case during an ASW search OT that it takes much more time to gain a detection of the target submarine than the operational test director (OTD) had expected. At this point, the OTD, typically concerned with the number of detections and encounters that his OT will generate, may introduce artificial means of detecting the target in order to speed up the detection process (e.g., require the target to actively ping for a short period). We have argued that, when used, the various artificial means of speeding up the detection process severely affect the realism of the search OT and limit the usefulness of the collected data with respect to providing unbiased estimates of system effectiveness.

We have suggested that fewer ASW search OT trials, but with maximum realism and more data collection, can provide for a far more insightful and credible assessment, than, say, twice as many unrealistic trials. Given that an OT is designed to yield fewer well-analyzed realistic trials, the OTD is still faced with the problem of controlling the OT, that is, controlling the average length of time that a test event lasts.

A. PURPOSE

This paper identifies test control rules that an OTD can employ from on-board the searching platform to allow for an efficient, free-play, open ocean (i.e., off-range), 24-hour-per-day OT. In particular, this paper documents the results of a simulation of an ASW search OT in which test control rules are used and explores the ramifications of the various test control rules on the number of trials expected and on the quality of the estimates of three search-related measures of effectiveness (MOEs.)

The basic test control premise described here is to stop the test event if the time without a detection/classification grows too long. Furthermore, if this long period passes again without detection/classification, then the OTD uses a different search scenario in which the size of the area being searched is shrunk. This process of observing the times to detection/classification, and then deciding whether to continue to the next search as

previously planned, stop (“truncate”) the current trial, or truncate the current trial and shrink the next box searched can be used to control ASW search OTs. What these “sequential test control rules” should be – for instance, how long until stopping the trial (*stopping rule*) and how much should the box be shrunk (*shrinkage rule*) – is the subject of much of this paper.

B. METHODOLOGY

A spreadsheet simulation was designed to allow for the exploration of several test control rules. In order to accomplish this, a straightforward model of the times to detection/classification was developed based on observations from a recent ASW search OT and our review of typical test plans and procedures. This model uses a fitted gamma distribution to represent the times to detection/classification that one might expect from a free-play ASW search OT.¹ Our simulation proceeds by first drawing random times to detect/classify from an appropriate gamma distribution. Next, the given test control rules are applied and fixed amounts of time for localization, attack, and repositioning are added. The simulation keeps track of how many detections and encounters occur for a given test duration. In addition, estimates of three search-related MOEs – median search rate (MdSR), search rate (SR), and mean search rate (MSR) – are compiled for the simulated OT.² Finally, this process is repeated 100 times for each test situation and the results (e.g., times to detect, number of trials, MdSR, SR, MSR) are stored as frequency tables (Appendix B).

Table 1 presents the various test situations that were simulated. Two system performance levels were examined: “System A” – a system that performs at a level similar to that of a system observed in a recent OT – and “System B” – a system that performs at half the System A level. That is, the average time to detect/classify for System A (while searching an 800 NM² box) was 7.54 hours, whereas the comparable System B value was 15.08 hours.

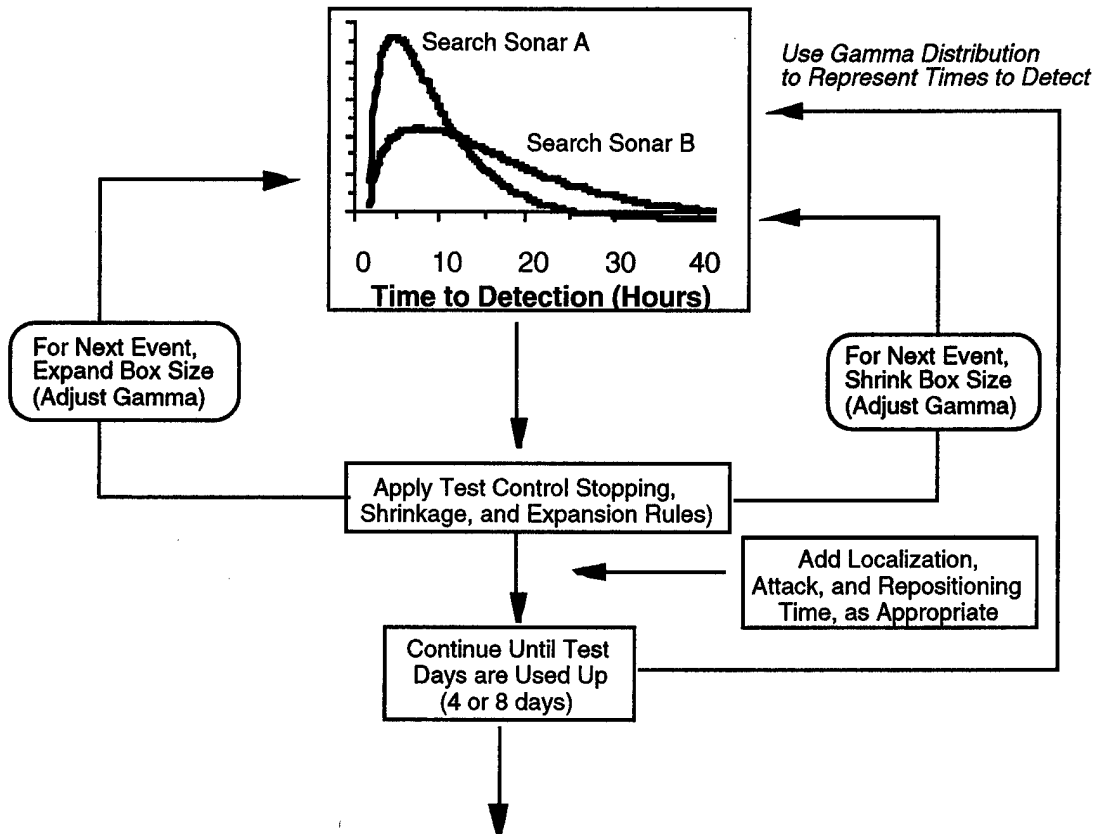
¹ A justification for the use of a gamma distribution is provided in Chapter II.

² Definitions for these MOEs can be found in Chapter II.

Table 1. Test Situations That Were Examined

Test Length (Days)	Localization and Attack Time (Hr)	Stopping Rule (Truncation Time - Hr)	Shrinkage Rule (%)
4 and 8	2, 4, and 8	12, 16, 20, 24	25 and 50

In all, 96 different test situations (runs) were simulated, each one with 100 trials, for a total of 9,600 simulated OTs. Figure 1 provides a schematic view of the simulation's operation. Based on the given set of test control rules and the observed times to detect/classify, the feedback loops (shown in red in Figure 1) serve to adjust the size of the area searched during the OT.³



Output: Number of Encounters, Truncations,
Times to Detect, Search-Related MOE Estimates

Figure 1. Simplified View of Simulation's Operation

³ Additional details of this simulation's operation can be found in Chapter II.

C. RESULTS

With respect to the employment of test control rules, the analyses presented in this document support the following conclusions. First, employing stopping rules for free-play ASW search OT can increase the number of encounters generated during the test and maintain elements of test realism. The use of such rules will be particularly valuable when the system under test performs significantly worse than pre-test expectations. For example, with an assumption of 2 hours (on average) for localization and attack and 8 days of testing, and using a 16-hour stopping rule and a 50 percent shrinkage rule, System A had a median value (based on 100 trials) of 17 encounters, whereas System B, with half the system performance level, had a median value of 15. (See Figure 2.) This relative test efficiency (i.e., the encounter sample size didn't decrease as fast as the system performance) results from the 16-hour stopping rule, which truncated some of the longest events that could have "wasted OT time" and, for some trials, led to smaller areas being searched.

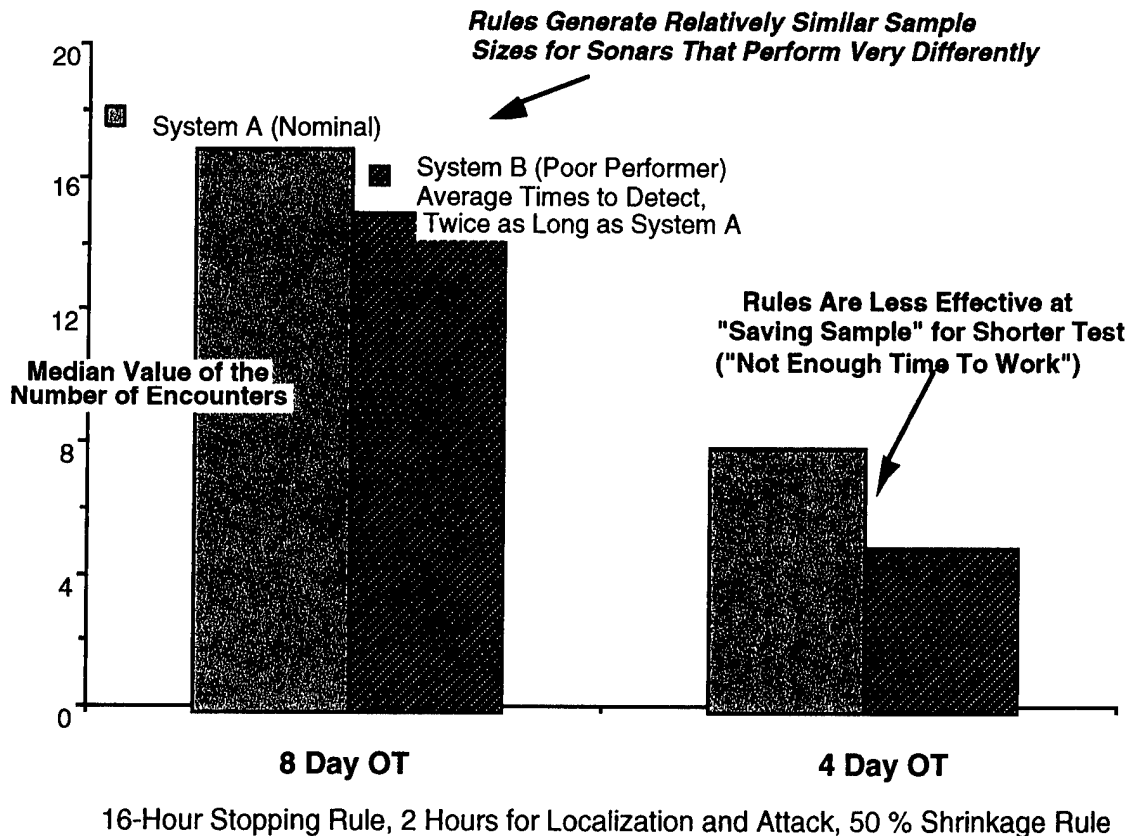


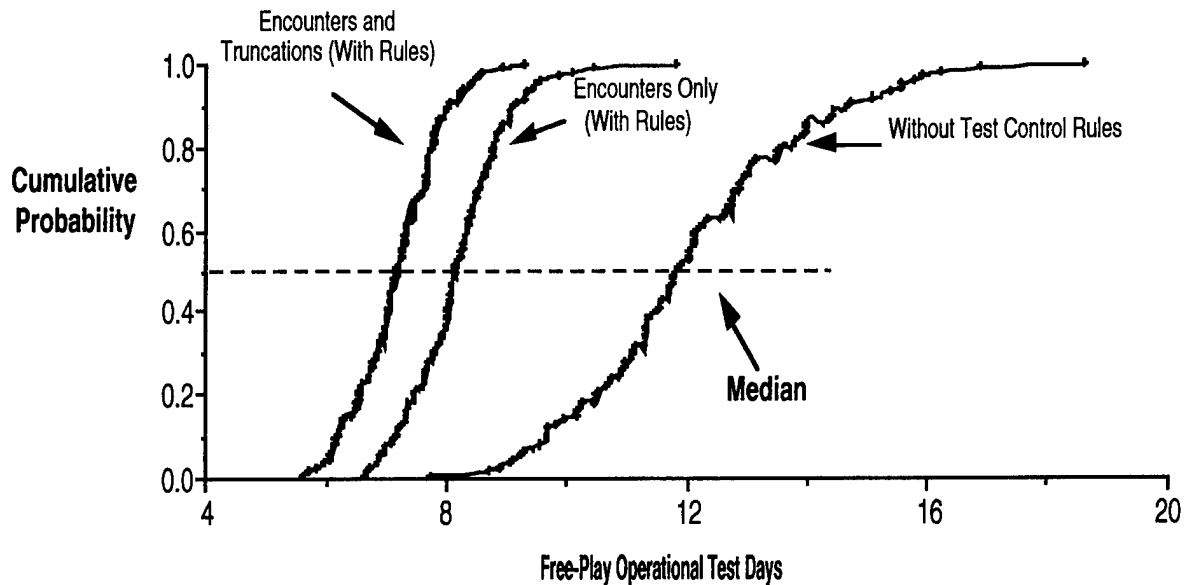
Figure 2. Example of Results

Longer test periods (on the order of 8 days or more) are more likely to be positively affected by the test control rules described in this document. Free-play test durations of 4 days or less will be only minimally affected by the rules described in this document.

The use of the 12-hour stopping rule with a 50 percent shrinkage rule led to unrealistically short times to detect/classify for some trials. This combination of rules led to situations where our test realism/vigilance rule-of-thumb – “maintain less than half a chance of detection/classification within 6 hours” – was violated. For the system performances examined (i.e., Systems A and B), stopping rules of 16, 20, or 24 hours, used in concert with 50 or 25 percent shrinkage rules, appeared satisfactory from this perspective.

Assuming an event-terminated free-play OT is to be conducted,⁴ the use of our test control rules can be expected to save substantial test time given that the system under test performs somewhat worse than expected. We considered a 15-encounter (i.e., events taken to completion) OT in which System B, the poorer performer, was tested without test control rules. We also simulated the same situation with the 16-hour stopping rule and the 50 percent shrinkage rule. In both cases, 100 trials were run (using the same initial set of random draws) and 4 hours were assumed for the average time to localize, attack, and reposition. Figure 3 shows the cumulative probability of completing such a 15-encounter OT as a function of the number of test days. Without the test control rules (curve shown in black), it takes between about 8 and 18 days, with a median value of about 12 days, to complete this free-play OT. By using the 16-hour/50 percent shrinkage rule (curve shown in red), this 15-encounter OT of System B takes between about 7 and 12 days, with a median value of about 8 days. That is, using the median values for comparison, these specific test rules allow this OT of System B to be completed in 33 percent less time. Figure 3 also shows the cumulative probability of completing a 15-event (encounters plus truncations) OT with the test control rules (curve shown in blue). This OT is completed in between 6 and 9 days, with a median value of about 7 days.

⁴ Most of this study assumed a time-terminated free-play OT.



**Figure 3. Time Savings Due to the Use of Test Control Rules:
Number of Days Required for a 15-Event OT of System B**

With respect to the search-related MOEs that were investigated:

- In the case of SR and MdSR, stopping rules of 16 and 20 hours appeared to represent a reasonable variance-reducing/realism-maintaining compromise. The increased sample sizes associated with using 16- and 20-hour stopping rules (relative to no stopping rule) led to decreased variance associated with the estimates of these MOEs. The longer stopping rule that was examined, 24 hours, led to fewer observed detections/ classifications, particularly for System B, and hence, greater variance in the estimation of search-related MOEs. As discussed above, the shorter stopping rule, 12 hours, often led to violations of our test realism rule.
- The MSR, because of the large variance associated with its estimation, does not appear to be a good choice for a search-related MOE.
- Given the employment of the test control rules described in this document, both MdSR and SR appear to represent satisfactory search-related MOEs. Whereas MdSR can be directly estimated from the observed events, an MLE procedure should be used to include censored data in estimates of SR.

- Given a “set of observations” (trial), a parametric bootstrap technique can be used to estimate the given search-related MOE and to attach confidence intervals. In addition, in the case of MdSR and SR, this technique can be used to arrive at statistically based conclusions (e.g., hypothesis testing) relative to predefined thresholds.⁵

D. CONCLUSIONS

Given the set of test control rules examined and for free-play ASW search OTs conducted on systems with performance expected to be similar to that of systems recently tested by the Navy, the 16- to 20-hour stopping rules appear best. For example, for the 16-hour stopping rule, if 16 hours pass after the start of the search without detection/classification of the target, the OTD should stop the trial and proceed to the next planned trial. If this period of time without detection/classification passes again on a different trial during the OT, the area size to be searched should be decreased by 25 or 50 percent. Additional OTD-directed truncations should be followed by further area shrinkages.

The examination of two “systems,” A and B, whose performance varied by a factor of two, demonstrated the robust behavior of the identified test control rules. That is, the same rules were used in either case (System A or B), yet acceptable numbers of encounters and expected levels of realism were maintained.

Given the usage of test control rules, the search-related measures, SR, defined as the area searched divided by the average time to detect/classify, and MdSR, defined as the area searched divided by the median time to detect/classify, could be used as high-level MOEs to aid assessments of system search effectiveness and, in particular, for comparisons to predefined thresholds or previous system performance.

⁵ Parametric bootstrap techniques use the structure of an assumed specific underlying distributional model. Alternatively, given such a construct, large-sample approximations based on the same parametric formulation could also be used to construct statistical confidence intervals. Nonparametric approaches, including the nonparametric bootstrap, offer other possible confidence interval approaches.

CHAPTER I

INTRODUCTION

I. INTRODUCTION

A previous IDA study (Ref. I-1) examined Operational Test and Evaluation (OT&E) concepts for attack submarines. This previous effort suggested that the operational effectiveness and suitability of an attack submarine be evaluated as a function of its specific mission and that a disciplined, logical approach that uses a framework composed of assessments of critical operational issues (COIs) be adopted. Five attack submarine COIs were identified: COVERTNESS, SEARCH, ATTACK, CONNECTIVITY, and AVAILABILITY.¹ Assessments of these COIs were meant to proceed via the estimation of a few high-level measures of effectiveness (MOEs) and a large number of measures of performance (MOPs). Furthermore, the study recommended that a comparative evaluation methodology be applied at all levels. For example, estimates of MOEs and MOPs for a given submarine (or submarine system) would be compared to Navy-defined thresholds *and* to estimates of current system performance. These estimates of current system performance might come from an analysis of past test, exercise, or operations data or, preferably, from "side-by-side" operational testing (Ref. I-2). The simulation study described in this paper is associated with the Anti-Submarine Warfare (ASW) mission and the SEARCH COI.²

A. NEED FOR TEST REALISM

Previous operational testing of the submarine or sonar search capability has not always been as realistic, and hence useful to decision makers, as one might like. Often, in the past, ASW OTs (and exercises) have involved a repetitive, forced encounter design. These forced encounter geometries are designed to increase the probability of detection in a "reasonable" length of time. Typically, the target ship and test platform (i.e., the searcher) are placed at different corners of a small box, perhaps an underwater acoustic range, and the target ship is required to follow a given track (or be at "tie points"

¹ The "all capitals" notation was used in Reference I-1 to designate the word as meaning the COI.

² MOEs and MOPs to support assessments of the ASW SEARCH COI have been identified (Ref. I-1). A key search-related MOE, which is being used by both the *New Attack Submarine* and *Seawolf* programs to aid ASW assessments, is search rate, defined in units of square nautical miles per hour. A detailed definition for search rate is given in Chapter II of this document.

at specific times) starting at the commencement of the exercise (COMEX). Depending on the circumstances, the test platform may be totally free to maneuver or be given a track to follow. Sonar contact on the part of either ship may permit either to maneuver at will. This design has been used to enhance the probability that the encounter will occur in the center of the box (or range) where weapons can be fired and more easily recovered.

This repetitive forced encounter design can lead to unrealistic conditions. For instance, Commanding Officers are not free to operate their submarines in the manner in which they would employ them in real combat and they may be confined to following demotivating "rudder orders" (particularly the target). If a forced encounter geometry is used to replicate an area clearance, a typical ASW search scenario, only the bow aspects of radiated noise are important, and there are generally no detections on opening geometries. This method does not yield stern aspects, and thus fails to test the ability of the test platform to "catch up" and exploit any proposed tactical speed enhancements. Furthermore, the sonarman is faced with ever-increasing signal-to-noise ratios in a forced encounter design. There is a suspicion that these conditions train him to wait when in doubt about detection or classification, expecting conditions to improve.

The repetitive COMEX-finish exercise (FINEX) sequence of "alert" periods leads to many artificialities. Sometimes, following COMEX, additional personnel who are more experienced, including the Commanding Officer, will muster at watch stations, thereby enhancing ship performance. Potentially detectable housekeeping operations, such as air charges, sanitary tank blowing (pumping), and dumping garbage, are delayed until after FINEX. The worst aspect of the COMEX-FINEX routine is the periodic expectation of a target detection (i.e., non-random, somewhat predictable, times from COMEX to detection).

A previous study of a surface ship sonar OT showed that measures of detection performance (i.e., probability of detection, percent holding time, time to initial detection) varied widely among test phases, depending, in large part, on how highly structured the particular test phase was. For example, the observed probability of detection during the highly structured BARSTUR/BSURE³ range phase was twice the value of that observed during the open ocean relatively "free play" test phase conducted in the mid-Atlantic (Refs. I-3 through I-6). During the highly structured, forced encounter-like phase, half of the initial detections came within 16.5 minutes of COMEX! Similarly, during the range

³ BARSTUR = Barking Sands Tactical Underwater Range, BSURE Barking Sands Underwater Range Expansion.

phase of the AN/BSY-1 Operational Evaluation (OPEVAL), detections were generally called within a few minutes of COMEX (Refs. I-7 and I-8). This latter OPEVAL also illustrated the problem of trying to test a long-range sensor, in this case the TB-23 towed hydrophone array, on a relatively confined underwater acoustic range.

In addition, there are some cases in which, as excessive time elapses after COMEX but before the predefined FINEX, the intensity of the sonar search rises to a maximum until the target is found. This artificial operator vigilance has been observed in several OTs.

With respect to the operational testing of the ASW search mission, we have recommended (Ref. I-1) that tests be conducted in the open ocean, "round-the-clock" (i.e., 24 hours per day) and designed to allow for free play of both the target and the searcher (test platform). For instance, the target would be given a realistic threat mission for the particular scenario under test and not simply be playing the target and "waiting to get shot." We concluded that conducting operational tests of sonars/submarines in this way and using a comparative evaluation strategy while measuring many MOPs would produce a credible assessment; thus the OT would represent a useful tool for the appropriate decision maker.

B. MOTIVATION FOR THIS STUDY

Efficiently designing a practical free-play, 24-hour-per-day, open-ocean OT of an ASW search system (e.g., submarine or sonar) represents a challenge for the OT community. A similar challenge exists for the training and tactics development communities. In the case of an OT, the operational test director (OTD), typically a lieutenant from OPTEVFOR, will have the additional responsibility of controlling this test so that a maximum of information is obtained, in as realistic a fashion as possible. The OTD's test control decisions must be made at sea, in real-time, typically while underway on the searching submarine, and with little communication to outside testers or operators.

In the past, OTDs have often been concerned with collecting enough data, that is, having enough detections and encounters on which to base their assessments. Of course, the previously discussed forced encounter test design can alleviate this concern but at the great cost of test realism and, ultimately, evaluation credibility. It is not unusual that, early in an OT, little sonar contact is held, perhaps going more than a day without a detection. This lack of detection becomes of great concern to the OTD. The OTD does

not want to return to OPTEVFOR, after “spending” all of his test resources, to report that only one or two trials (detections and encounters) were accomplished during his OT. This small sample size might preclude COMOPTEVFOR from resolving system COIs and issuing a final report. That is, more OT would likely be required.

At this point in the OT (i.e., after some long period without a detection), artificial means of detecting the target submarine are often introduced by the OTD. Perhaps augmentation to increase the radiated noise levels is turned on or increased to unrealistically loud levels.⁴ If the run had not been a free-play event and the OTD knew the approximate location of the target, “hints” might be given (e.g., “try looking to the southeast”). Targets have been known to introduce sound shorts, transmit active pings (in the hope of being detected), and create artificial transients (“go bang a hammer on the torpedo tube door”) to aid the searcher’s classification efforts.⁵ Obviously, these methods of speeding up the detection/classification process are unrealistic and render the search-related data that are collected of little value.

The above concern with having enough “trials” seems to be associated with a somewhat misguided approach to dealing with the inherent variance associated with the search process. The belief, apparently, is that, given enough trials, reasonable average values of MOEs (e.g., probability of detection) can be obtained. Of course, there are many causes of the variance associated with estimates of search-related MOEs. The acoustic environment, crew performance, and searcher and target tactics can all contribute to this variance. One cannot reasonably expect to do the hundreds or even thousands of trials that would be required to sort out *or average out* all of the potential causes of variance. The current approach seems to consider the causes of this variance as somehow random processes that are out of our control and, furthermore, of no particular interest.

We have suggested a new approach. Advances in information technology have led to the possibility of recording far more data in an unintrusive manner during the OT. For instance, high-density digital recorders can collect raw acoustic data, and built-in automatic data loggers can keep track of sonarman actions. These advances can allow individual searches (i.e., trials) to be much more valuable to the tester. Instead of simply

⁴ The use of externally mounted augmentation devices has led to numerous problems that have confounded the results of both the AN/BSY-1 and AN/BQQ-5D OPEVALs (Ref. I-9 and references therein).

⁵ For instance, see page 5 of Ref. I-10.

estimating one or two high-level MOEs, many MOPs can be estimated. For instance, "sonar equation parameters" such as recognition differential can be estimated from acoustic recordings and provide insight into system performance. The conclusion is that fewer trials, but with maximum realism and more data collection, can provide for a far more insightful and credible assessment than, say, twice as many unrealistic trials.⁶

Even given the above expectation that fewer well-analyzed realistic trials are more valuable than larger numbers of unrealistic trials, the OTD will still need a mechanism, or rules, to allow some measure of control over the average length of time that an encounter lasts. Controlling this average length of time, from on-board the searching platform during the actual OT, while maintaining elements of operational realism represents a potential obstacle to the employment of free-play OT designs.

On-board the searching platform, often a submarine, the OTD may have accurate knowledge of very few parameters. For instance, detection ranges will not necessarily be accurately known until weeks after the OT when the search platform/target position reconstructions are complete. The time from COMEX to detection/classification represents one of the few, perhaps only, sources of information that are, in general, relatively accurately known in real-time by the OTD. It is these times, and the information that we can extract from them, that we propose as a basis for our practical test control rules. This paper identifies practical test control rules that an OTD can employ from on-board the searching platform to allow for an efficient free-play, open-ocean, 24-hour-per-day OT. In addition, this paper characterizes some of the properties of these test control rules.

The basic idea is to stop the test if the time without a detection/classification grows too long.⁷ Furthermore, if this long period passes again without detection/classification, then the OTD needs to use a different search scenario in which the size of the area being searched is shrunk. This process of observing the times to detection/classification, and then deciding whether to continue to the next search as previously planned, stop ("truncate") the current trial, or truncate the current trial and shrink the next box searched can be used to control ASW search OTs. What these

⁶ Of course, an infinite number of totally unrealistic trials would be of no value, statistical or otherwise.

⁷ This period of time (to detection/classification) might be longer than expected for several reasons. For example, the sonar system may not be as effective as previously believed, the crew may not have been fully trained, the target may be quieter than expected, or the acoustic environment (noise field and transmission loss) may be more challenging than predicted.

“sequential test control rules” should be – for instance, how long until stopping the trial and how much should the box be shrunk – is the subject of much of this paper.

REFERENCES

- I-1. *Operational Test and Evaluation (OT&E) Concepts for Attack Submarines*, IDA Paper P-2843, 8 November 1993.
- I-2. *Side-by-Side Testing in Submarine Warfare System OT&E*, IDA Memorandum for DOT&E, 1 December 1994.
- I-3. *Review and Analyses of COMOPTEVFOR's Follow-On Operational Test and Evaluation (OT-IIIC) of the Antisubmarine Warfare Combat System Integration Program (AN/SQQ-89(V)3)*, IDA Memorandum for DOT&E, 8 September 1993, pages 1-8.
- I-4. *Follow-On Operational Test and Evaluation (OT-IIIC) of the Antisubmarine Warfare Combat System Integration Program (AN/SQQ-89(V)3)*, COMOPTEVFOR, 1 July 1993.
- I-5. *Antisubmarine Warfare Combat System Integration Program (AN/SQQ-89(V)4) Follow-On Operational Test and Evaluation (OT-IIIE)*, COMOPTEVFOR, 2 June 1992.
- I-6. *Follow-On Operational Test and Evaluation (OT-IIID) of the Antisubmarine Warfare Combat System Integration Program (AN/SQQ-89(V)3)*, COMOPTEVFOR, 28 August 1992.
- I-7. *Review of the OPTEVFOR Evaluation Report on the Operational Evaluation of the Combat Control/Acoustic (CC/A) Set AN/BSY-1(V)*, IDA Memorandum for DOT&E, 7 January 1992.
- I-8. *Combat Control/Acoustic (CC/A) Set AN/BSY-1(V) Operational Evaluation*, COMOPTEVFOR, 16 October 1991.
- I-9. *Documentation of the Submarine Threat Replication Problem*, IDA Memorandum for DOT&E, 14 February 1994.
- I-10. *MODS ADCAP OT-IIIC/D: Final Test Period Trip Report*, IDA Memorandum for DOT&E, 26 December 1995.

CHAPTER II

METHODOLOGY

II. METHODOLOGY

In this chapter, we describe the procedures followed, assumptions made, and calculations performed, in order to develop and study test control rules for ASW search OT. Basically, we simulate an operational test of an ASW search system for the "one-on-one" case (i.e., submarine versus submarine).¹ We develop a model for the times to detection/classification for a free-play, 24-hour-per-day, open-ocean, ASW search OT. Next, we use this model to generate pseudo-random variates to serve as realistic times to detection/classification. These times, with the reasonable addition of time for localization, attack, and repositioning after the encounter, are then summed until the desired number of test days are used up. All along, we follow potential test control rules that define when the OTD should stop a trial and/or "shrink" the search area and by how much.

Our discussion begins with a brief review of idealized random search theory.

A. RANDOM SEARCH THEORY

When a ship or submarine is conducting a random search of an area for a target whose location is uniformly distributed over the ocean, the time between detections will be exponentially distributed with a mean time to detection ($1/\lambda$) dependent upon the searcher's effective detection range and the target and searcher speeds. For a given search time (t), the probability distribution function is given as:

$$P(t) = \lambda e^{-(\lambda t)} \quad \text{Equation II-1}$$

This "exponential detection law" was described in detail by B. O. Koopman in 1946 (Ref. II-1).² In addition to a uniform distribution of target density,³ this model assumes that the relative motions of the searcher and target are random (e.g., uncorrelated) and that the size of the area is much larger than the effective detection

¹ This methodology could be extended to the "one-on-many" or "many-on-one" cases.

² The searcher's performance (e.g., detection range) and the target and searcher speeds are "wrapped up" within λ .

³ That is, the target's location is equally likely anywhere within the area to be searched.

range of the search platform. If the target can detect the searcher before the searcher can detect the target, then target motion can become correlated (e.g., the target may choose to avoid the searcher), and this model will not necessarily be a good representation of the search process. If the search area and effective detection range are of similar sizes, then the searcher will be “looking” in areas outside of the defined search area during some periods of his random search, areas where target density is necessarily zero, and, again, this exponential search model may be of limited value.⁴ With respect to mission and test planning, these assumptions have often been acceptable, and random search theory has been widely applied.⁵

Koopman expresses the cumulative probability of detection ($\text{Prob}[\text{detect} \leq t]$) when the searching is done continuously under unchanging conditions as:

$$\text{CumP}(W, L) = 1 - e^{-\left(\frac{WL}{A}\right)} \quad \text{Equation II-2}$$

where W = the effective sweepwidth ($2 \times$ effective detection range⁶), L = total length of the observer’s path (relative speed \times search time), and A = area size. By setting search rate (SR) = $W \times$ relative speed, we can restate this equation, for a given search time, as:

$$\text{CumP}(SR) = 1 - e^{-\left(\frac{SR \times t}{A}\right)} \quad \text{Equation II-3}$$

Furthermore, if SR is defined as the size of the area to be searched divided by the average time to a detection,⁷ then a natural estimate of the cumulative probability of detection can be based on the observed times to detection as follows:

$$\text{EstCumP}(t) = 1 - e^{-\left(\frac{t}{\frac{1}{n} \sum_{i=1}^n t_i}\right)} \quad \text{Equation II-4}$$

⁴ This phenomenon is sometimes referred to as an “edge effect.”

⁵ A few studies familiar to the authors are given in Refs. II-2 through II-5. Undoubtedly, there are many more applications of random search theory.

⁶ This effective detection range is based on the simplified concept of a “definite range law detector.” (See Ref. I-1, page 20.) Often the sonar’s computed median detection range (MDR), based on an estimation of the sensor’s acoustic figure-of-merit (FOM) and the environment-specific transmission loss curve (as a function of range), is used as a surrogate for effective detection range.

⁷ This formulation of search rate and its relationship to sweepwidth has been previously discussed (Refs. II-1, II-6, and II-7).

In Equation II-4, n = the number of observed detections. Figure II-1 shows this classic formulation of the cumulative probability of detection for one value of λ .

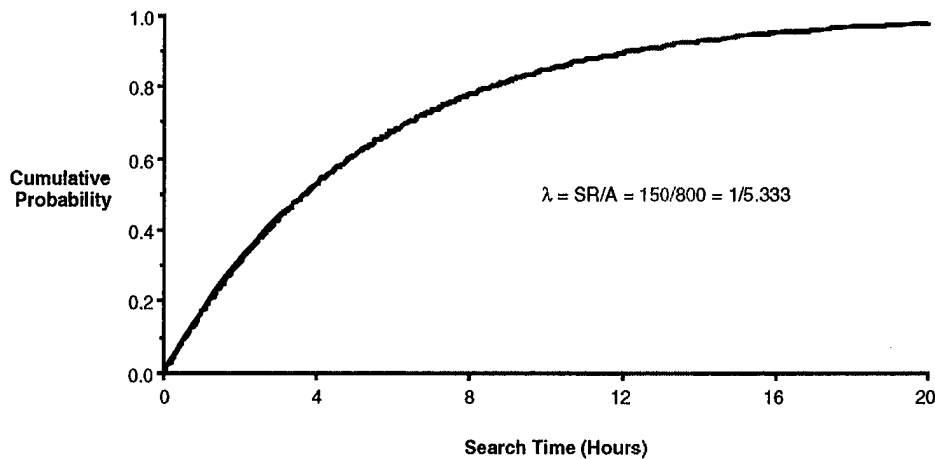


Figure II-1. Classic Exponential Random Search Model

Since λ can be estimated as SR/A , variations in A (or SR) lead to linear changes in SR (or A) for a given constant λ . Note that $1/\lambda$ is the mean time to detection. The implication, for instance, is that doubling the area size (for a given sensor) or halving the searcher performance (i.e., search rate) will double the value of $1/\lambda$. Therefore, doubling the area size to be searched without improving the sensor leads to a mean time to detection that is twice as long as the case for the initial area size (for this ideal case). Figure II-2 illustrates the effect of changes in λ on the cumulative probability curves.

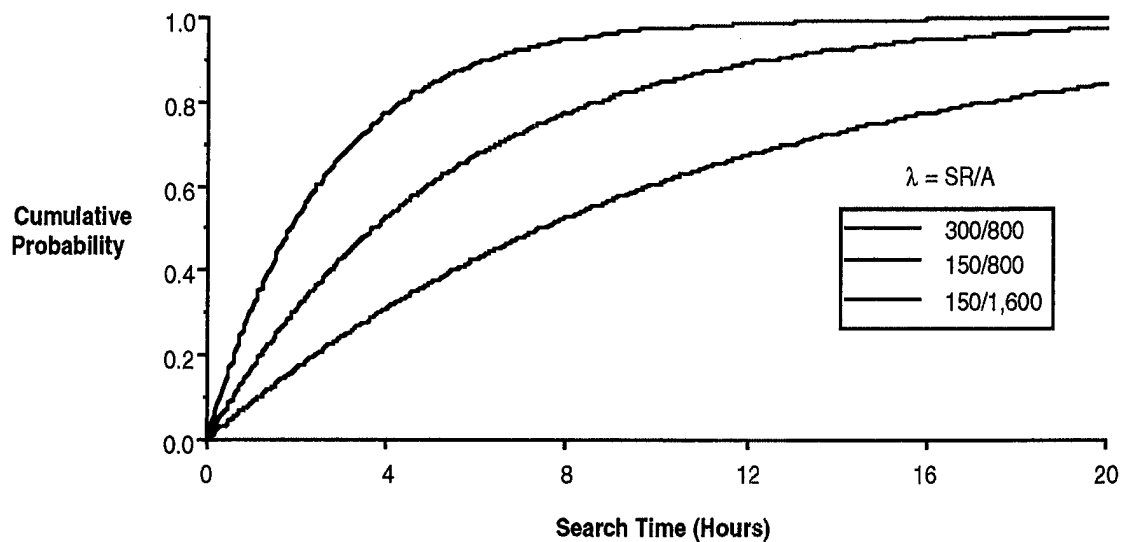


Figure II-2. Cumulative Probability of Detection as a Function of λ (= SR/A)

B. OBSERVATIONS FROM A RECENT OPERATIONAL TEST

This section describes some results from a 24-hour-per-day, open-ocean, relatively free-play operational test of a submarine sonar that was conducted in 1994.⁸ After developing a conceptual model for the times to detection/classification, in the next section, these 1994 OT results will be used to “fit” a specific model. Table II-1 presents some of the search-relevant results.

Table II-1. Measured Search Durations and Search Rates

Trial #	Search Duration (t_i) (minutes)	Area Size (a_i) (NM ²)	Search Rate ($sr_i = a_i/t_i$) (NM ² /Hr)
1	251	400	95.6
2	23	400	1,043.5
3	403	400	59.6
4	157	400	152.9
5	104	400	230.8
6	354	400	67.8
7	326	400	73.6
8	242	400	99.2
9	124	800	387.1
10	115	800	417.4
11	1,332	800	36.0
12	309	800	155.3
13	298	800	161.1

The measured search duration is best characterized as a time from COMEX to detection/classification. Importantly, the times to “detection” are not necessarily known. Rather, the time at which a signal or signals are classified to the degree that

⁸ Some classified details of this testing can be found in Reference II-8 and references therein.

some action by the search platform can occur may be the more relevant measure of ASW search effectiveness. Often, detection and classification appear to occur at the same time. One can imagine a signal being “detected” by the sonarman or perhaps his computer, but not recognized as a target of interest until some later time. The times in Table II-1 represent the times to detection/classification for those detections/classifications that turned out to be of the submarine of interest (i.e., the target). In our first departure from the ideal “random search” case, we recognize that the measured search durations actually represent the time from COMEX to a detection/classification (vice simply the time to detection). We justify further use of random search theory by arguing that an analogy to the definite range law detector, a “definite range law classifier” (effective classification sweepwidth) exists, with all the same attendant limitations and assumptions (as described above).

Table II-2 presents the average time to detection/classification based on the observed data.⁹ The average time to detection/classification appears to be about twice (within 7 percent of twice) as long in the 800 NM² box as in the 400 NM² box. This suggests that, for these operational test data, the linear relationship (discussed earlier) between searcher performance and area size holds. (For instance, edge effects did not appear to be important for these data.) Assuming that this linear relationship roughly holds, we have normalized the times to detection/classification (t_i) for an 800 NM² area size and present the average search duration for all thirteen observations in the last column.

Table II-2. Average Time to Detection/Classification (hours)

Parameter	Area Size = 400 NM ²	Area Size = 800 NM ²	All (Normalized at 800 NM ²)
Sample Size	8	5	13
Average $\{t_i\}$	3.88	7.26	7.56

Several measures of search effectiveness can be computed from the data shown in Table II-1. Three of these measures, search rate (SR), median search rate (MdSR), and mean search rate (MSR), are defined below and presented in Table II-3.

⁹ The inverse of this average time to detect/classify can be thought of as an estimate of the searcher’s characteristic “detection/classification rate” (for a given area size or, alternatively, target density).

$$SR = \frac{A}{\frac{1}{n} \sum_{i=1}^n t_i (A/a_i)} \quad \text{Equation II-5a}$$

$$MdSR = Median \left\{ \frac{a_1}{t_1}, \frac{a_2}{t_2}, \frac{a_3}{t_3}, \dots, \frac{a_n}{t_n} \right\} \quad \text{Equation II-5b}$$

$$MSR = \frac{1}{n} \sum_{i=1}^n \frac{a_i}{t_i} \quad \text{Equation II-5c}$$

A = the area size of interest (e.g., to be normalized to), a_i = the size of the i th area searched, t_i = the time from COMEX to detection/classification of the i th search, and n = the number of searches. Note that the calculation of SR generally requires the (linear) normalization (" A/a_i " factor in Equation II-5a) of times to detect/classify if the area sizes are changed during the OT.

Table II-3. Estimates of Search Effectiveness for 13 Observations

Parameter	Value (NM ² /Hr)
SR	105.8
MdSR	152.9
MSR	229.2

Given the above estimates of search effectiveness measures and the 13 observed times to detection/classification, one can compute approximate confidence intervals (or alternatively, conduct specific hypothesis tests). Conventional parametric techniques for computing confidence intervals require that the observations correspond to a random sample from a known probability distribution and that the exact sampling distribution for the given test statistic (e.g., mean, median, maximum) is known. The latter requirement, for the exact sampling distribution, is, in general, not possible. However, using the 13 observations of t_i , one can compute approximate confidence intervals for the above estimates using resampling techniques such as the bootstrap.

To generate "nonparametric bootstrap" confidence intervals, we first randomly draw (with replacement) 13 t_i 's from the observed sample. From these 13 t_i 's, or bootstrap sample, we compute the parameters of interest, in this case, SR, MdSR, and MSR. We repeat this process, in this case 2,000 times, and then order these bootstrap estimates of the particular measures of search effectiveness. An approximate confidence interval of

$\alpha\%$ is represented by the endpoints of the middle $2,000 \times \alpha$ bootstrap estimates. This technique is referred to as the "percentile interval" method.¹⁰

Table II-4 presents these nonparametric bootstrap (approximate) confidence intervals for the five measures of Table II-3 (for α values of 80, 90, and 95%). The interval lengths associated with SR are the shortest. The interval lengths associated with MSR are the longest (3 times that of SR). The 80% confidence interval length associated with MdSR is similar to that for SR. However, the 90% and 95% interval lengths are about 1.5 times longer for MdSR vice SR. These results suggest that estimates of SR, and to a degree MdSR, will have lower variance than MSR.

Table II-4. Nonparametric Approximate Confidence Intervals (C.I.)

% C.I.	SR	MdSR	MSR
80	83.5 - 145.0	95.6 - 161.1	141.4 - 327.2
90	77.7 - 157.8	73.6 - 230.8	127.6 - 360.5
95	73.4 - 173.3	73.6 - 230.8	116.5 - 390.1

C. DEVELOPMENT OF A TIME TO DETECTION/CLASSIFICATION MODEL FOR AN ASW SEARCH OT

Significantly, there was one feature of this 1994 operational test that did not satisfy the assumptions of ideal random search theory. After each encounter, the OTD, via the test plan, repositioned the searcher and target to the starting points for the next trial. These starting points (locations at COMEX) were designed such that they would place the searcher, necessarily, over the acoustic detection/classification horizon. Therefore, no detections could occur at the shortest time intervals. Rather, there must be some minimum time delay (perhaps when the searcher and target are heading directly at each other at their highest speeds) until the target gets within the searcher's detection/classification range (e.g., definite range law classifier). We might envision this situation as still leading to an exponential distribution of times to detection/classification, but with some initial time delay. Equation II-5 captures this "delayed exponential" situation, where C = the time delay.

$$P(t) = \lambda e^{-\lambda(t-C)} \quad \text{for } t > C \quad \text{Equation II-6}^{11}$$

¹⁰ See Ref. II-9, Chapter 13, and, for additional general information on the bootstrap, Refs. II-10 and II-11.

If one takes $\lambda = SR/A = 150/800$, as in Figure II-1, and, in addition, adds a 1.0 hour time delay ($C = 1$), then the density function shown in Figure II-3 results.

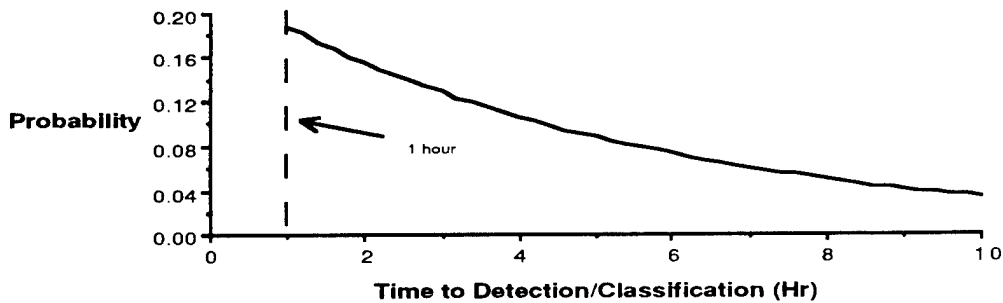


Figure II-3. Delayed Exponential Model

We also recognize that the searcher's actual detection/classification performance may vary from trial to trial. Perhaps the environment gets louder or quieter, or the target radiates more or less sound, or the sonar operator's recognition differential changes from trial to trial and thus impacts the searcher's detection/classification range. We can model this variance as a random variable added to the mean time to detect/classify ($1/\lambda = \text{mean time}$). For this examination, we chose this random variable from a Normal distribution with mean (μ) equal to zero and standard deviation equal to σ .¹²

Next, one might consider the initial time delays as related to the relative target speeds, the initial COMEX separations after repositioning, and the searcher's detection/classification range. For a typical OT, the separations at COMEX will vary with each OPTEVFOR run plan. There may be a few run plans that have the searcher and target at approximately opposite corners of the box (biggest separation), and a few that put the players on opposite sides of the box, and still more that place them just over the acoustic horizon (perhaps across some imaginary boundary). These variations in repositioning separations can be modeled as a finite number of possible repositioning separations. In the present case, we envision three separations: long range (opposite corners), medium range (opposite long sides of a rectangular box), and short range (opposite short sides of a rectangular box).¹³ In addition, searcher detection/classification

¹¹ This delayed exponential is also referred to as a two-parameter exponential distribution.

¹² We chose a Normal distribution in order to represent the combination of the many factors that can lead to variance in system detection/classification time.

¹³ For a 40 NM \times 20 NM (800 NM²) rectangular box, one can imagine separations at COMEX of about 40 NM (opposite corners), 30 NM (opposite sides (long)), and 15 NM (opposite side (short)). At a reasonable maximum relative closure speed of 20 knots (10 knots searcher and 10 knots target), this would imply minimum time delays of 2.00, 1.50, and 0.75 hours for the three separation cases described above, respectively.

performance (discussed above) can lead to variance in the expected value of the time delay (C). Hence, this variance in time delay can be modeled as a random variable added to a nominal time delay, with the nominal time delay chosen from some finite set of repositioning separations. Again, a Normal distribution with $\mu = 0$ and a standard deviation $= \sigma$ are used to generate the random variables for addition to the nominal time. Note that the same standard deviation (and random draw) is associated with both the average time to detect/classify ($1/\lambda$) and the time delay (C). Thus, $1/\lambda$ and C are correlated in this model.¹⁴ That is, $P(t) = \lambda e^{-\lambda(t-C)}$ where $t > 0$, $1/\lambda = 1/\lambda_1 + D$, $C = C_1 + D$, and D is a random variable drawn from a Normal distribution $(0, \sigma^2)$.

Figure II-4 illustrates the above model for six cases (two each with the initial nominal time delay (C_1) set at 0.75, 1.50, and 2.00 hours – see footnote 10. In Figure II-4, $1/\lambda_1 = A/SR = 800/150 = 5.33$ and $\sigma = 0.5$. The σ value of 0.5 was chosen solely for illustration.

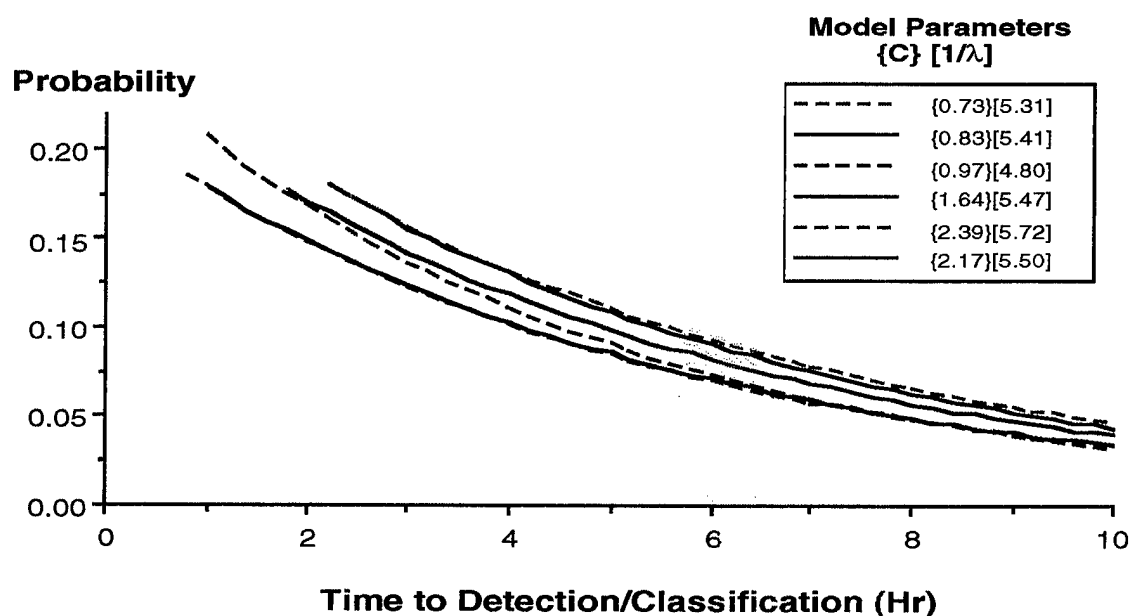


Figure II-4. Six Delayed (Two-Parameter) Exponential Distributions

¹⁴ This correlation is due to the fact that the searcher performance (or detection/classification range) affects both the exponential decay and the time delay. For instance, increased ambient noise would lead to a decrease in the expected detection range and affect the exponential decay term. In addition, this same increased ambient noise and concomitant decreased detection range would, on average, cause the initial time delay to be longer since the target would need to get closer to the searcher before a detection could be made. In any case, removing this correlation, that is, using independent random draws, does not affect the outcome of our argument – that a gamma distribution represents a good model for representing the times to detection/classification expected from an OT. See the ensuing discussion.

The impact of the different initial searcher-target separations can be seen (Figure II-4) as different time delays to the onset of first expected time to detection/classification. In addition, the variability in $1/\lambda$ (the mean time to detect/classify) can be seen in the different decay rates of the six curves. We might think of any given search OT as leading to observed times “drawn” from a combination of some unknown number of these delayed exponential curves. Continuing with these thoughts, we generated 30,000 times to detect/classify from 30 delayed exponential distributions (prepared as described above, i.e., ten each with nominal reposition separation times of 0.75, 1.50, and 2.00 hours). Figure II-5 presents the resultant histogram of the combination (or equally weighted mixture) of 30 delayed exponential distributions.

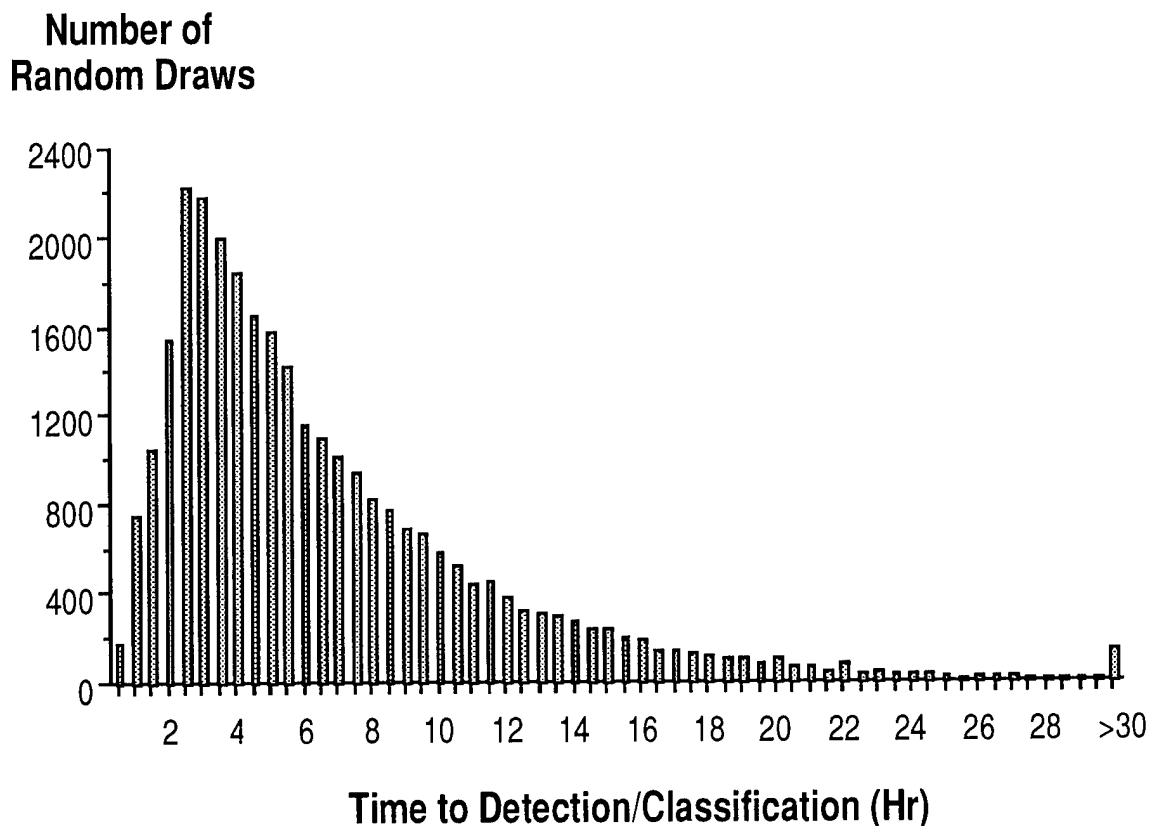


Figure II-5. Histogram of 30 ($\times 1000$) Random Draws from a Combined Delayed Exponential Distribution

The above histogram suggests a probability density function for the times to detect/classify for a free-play search OT. The initial time delay associated with this function followed by a relatively smooth increase in density and, finally, by essentially

exponential decay suggested to us that the gamma distribution could be used to model these times to detect/classify. Using a mathematical representation or model, in this case a gamma distribution, to represent these times to detect/classify is a way to simulate a search OT (in a reasonably efficient manner).

Intuitively, one can imagine the times to detection/classification (t_i s) distributed in a manner analogous to the r th event of a Poisson process. For example, first the target's acoustic energy must be detected and displayed by the sonar. Next, after examining this acoustic energy, enough information, perhaps several characteristic tones of sufficient strength, must be identified by the sonarman to make a classification. This waiting time to the r th event in a series of events happening in accordance with a Poisson process (at a constant rate of events per unit time) obeys a gamma probability law (Ref. II-12). Alternatively, one might consider the t_i s as arising from a mixture of independent standard exponential variables (X_1, \dots, X_r) (perhaps with the time delays and time decays arising from independent exponential distributions), then the probability density function of their linear combination is represented by a general gamma (or general Erlang) distribution (Ref. II-13).

Gamma distributions have been used as representations of many physical situations. In particular, they have been used to make realistic adjustments to exponential distributions in representing lifetimes and other random processes in time (Ref. II-13, page 343). The next section describes the gamma distribution and provides "fits" to observations.

D. FITS TO A GAMMA DISTRIBUTION

The probability density function for a gamma distribution is:

$$g(t; \alpha, \beta) = \frac{1}{\Gamma(\alpha)\beta^\alpha} t^{\alpha-1} e^{-\frac{t}{\beta}}, \quad 0 < t < \infty \quad \text{Equation II-7}$$

where α is a shape parameter ($\alpha > 0$) and β is a scale parameter ($\beta > 0$). The gamma function $\Gamma(\alpha) = (\alpha-1)!$. Furthermore, for $\alpha = 1$, the gamma distribution reduces to the exponential distribution with $\beta = 1/\lambda$ (Refs. II-13 and II-14). When $\alpha > 1$, the gamma distribution takes on the basic shape shown in Figure II-6.

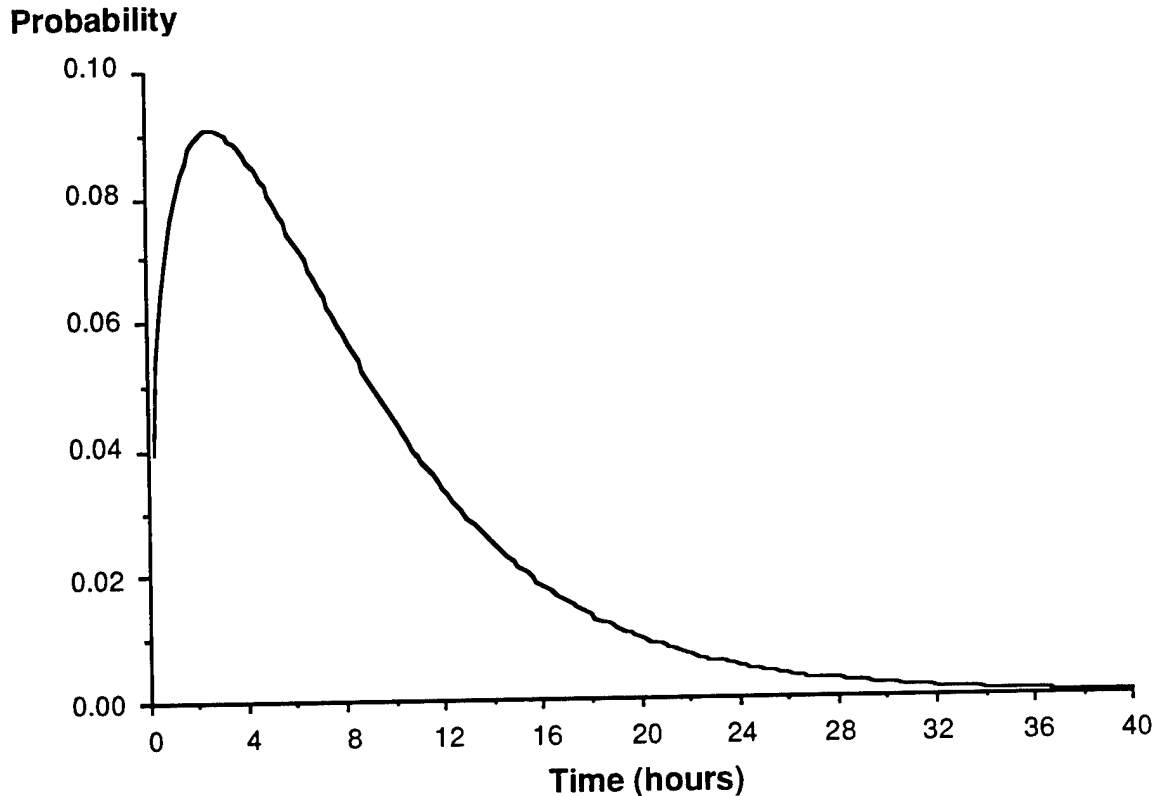


Figure II-6. Shape of Gamma Distribution for $\alpha = 1.5$ and $\beta = 5.33$

A comparison of Figures II-6 and II-5 suggests that the gamma distribution may be adequate for modeling the times to detect/classify of a free-play search OT with repositioning over the acoustic horizon after each encounter. That is, the combination of several delayed exponential distributions, which can be thought of as contributing to the observed times to detect/classify, can be represented (approximately) by a single gamma distribution.

We can estimate the parameters of the gamma distribution based on the observed times to detect/classify reported in Table II-1. First, the “method of matching moments” can be used (Ref. II-13). For this technique, the average and variance of the times to detect/classify are related to the parameters, α and β , of the gamma distribution as shown below .

$$\beta'\alpha' = \text{sample average} \quad \text{Equation II-8a}$$

$$\beta'^2\alpha' = \text{sample variance} \quad \text{Equation II-8b}$$

The primes (') on α and β are meant to distinguish the estimator from the parameter.

Noting that the average time to detect/classify is 7.56 hours (normalized to an 800 NM² box) and the variance is 35.13 hours,¹⁵ one can compute α' and β' by simultaneously solving the two equations shown above. Following this method leads to $\alpha' = 1.63$ and $\beta' = 4.65$.

A second technique to estimate the parameters of the gamma distribution is to minimize the squared differences between the cumulative gamma distribution and the observed cumulative probability of detection/classification as a function of time. Figure II-7 plots the ordered normalized (to 800 NM²) times to detect/classify (from Table II-1). This provides an empirical cumulative probability of detection/classification curve as a function of time. Using the above "least-squares" approach, one can solve for α' and β' .¹⁶ The solid line in Figure II-7 corresponds to the cumulative gamma distribution fitted in this way.

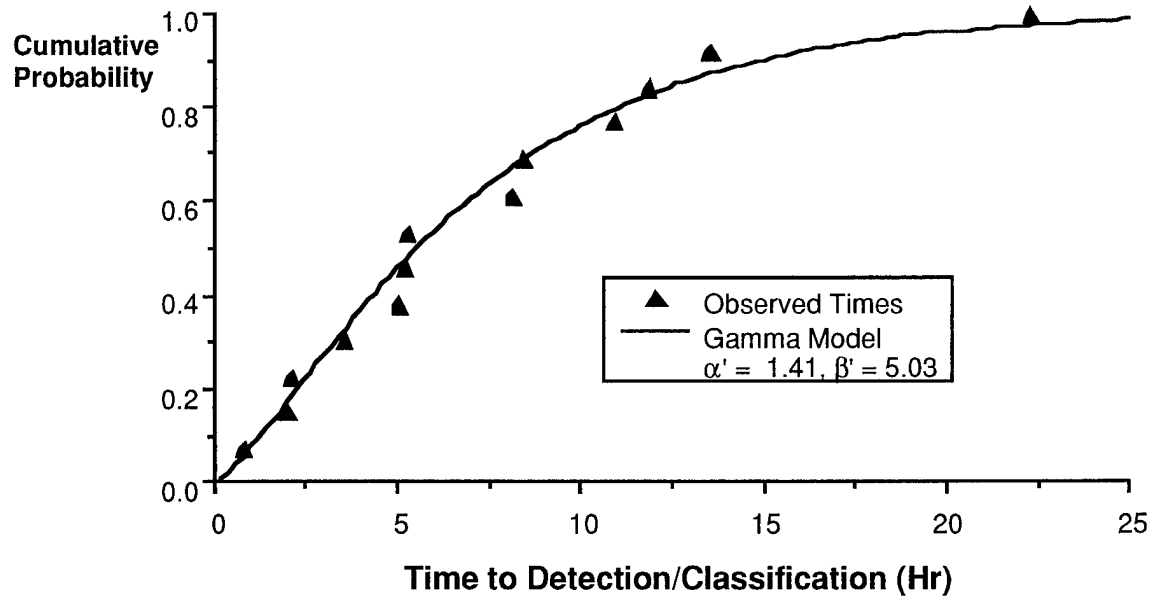


Figure II-7. Cumulative Probability Distribution for Times to Detect/Classify (Normalized to 800 NM²) and Cumulative Gamma Distribution (Fit With Least-Squares)

A final technique, widely accepted and considered theoretically superior, is the method of maximum likelihood estimation (MLE) (Ref. II-15). In this case, the likelihood function (L) to be maximized is

¹⁵ Sample variance is computed as $\frac{n \sum t_i^2 - (\sum t_i)^2}{n(n-1)}$ where n = the number of observations.

¹⁶ The *Microsoft EXCEL™ Solver* function was used to determine iteratively the least-squares solution. In order to ensure the correct shape, α was constrained to be greater than 1.

$$L(\alpha, \beta; \text{data}) = \prod_{i=1}^n g(t_i; \alpha, \beta) \quad \text{Equation II-9}$$

where g is the gamma density function (Equation II-7).

Again, one can iteratively solve this equation, and obtain estimates of α and β .¹⁷ Table II-5 presents the estimates of α and β computed by the three methods outlined above. Figure II-8 compares the three “fits” to the observed data via a plot of the cumulative probability of detection/classification. As can be seen in Figure II-8, the MLE and matching moments methods yield very similar results for these data.¹⁸

Table II-5. Estimates of α and β

Method	α'	β'
Matching Moments	1.63	4.65
Least-Squares	1.41	5.03
MLE	1.66	4.54

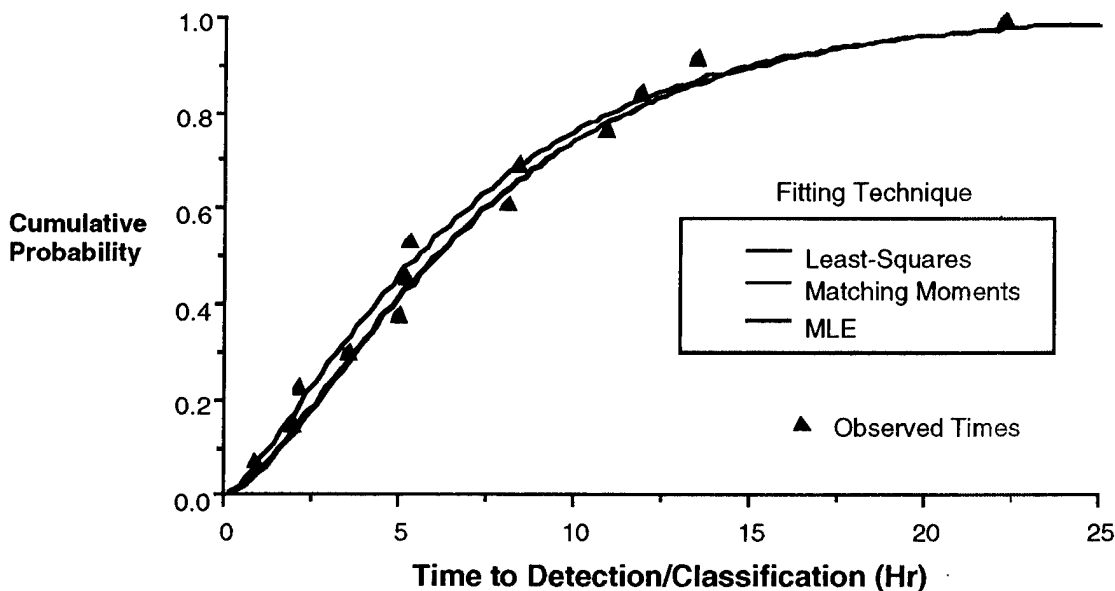


Figure II-8. Comparison of Various Fits to a Gamma Distribution

¹⁷ Microsoft EXCEL™ Solver was used for the iterative calculations. Again, α was constrained to be greater than 1.

¹⁸ Note that the observed average (normalized to 800 NM²) time to detect/classify was 7.56 hours (Table II-2). The MLE estimate of the mean time to detect/classify, $\beta'\alpha' = 7.54$ hours, is in good (<1 percent difference) agreement.

An additional advantage of the MLE technique is that censored data, for instance, for trials in which the OTD stops the test at 20 hours without a detection/classification, can be included in the likelihood estimation. A modification of Equation II-9 that incorporates a "survival probability" (\bar{G}) can be used to permit censored data observations (Ref. II-16):

$$L(\alpha, \beta; data) = \prod_{i=1}^n [g(t_i; \alpha, \beta)]^{I_i} [\bar{G}(m; \alpha, \beta)]^{1-I_i}. \quad \text{Equation II-10}$$

The indicator (I_i) is as follows: $I_i = 1$ if a detection/classification occurs and 0 if the trial is truncated (i.e., if no detection/classification time is observed because of trial truncation). The parameter "m" of Equation II-10 is the stopping time (e.g., 20 hours – if no detection/classification is observed within 20 hours, stop the trial). The survival probability is calculated as shown below with g being the gamma density function (Equation II-7):

$$\bar{G}(m; \alpha, \beta) = \int_m^{\infty} g(t'; \alpha, \beta) dt' \quad \text{Equation II-11}$$

where m is the time to stopping the trial without a detection/classification (e.g., 20 hours).

Based on the above discussions, we chose the MLE technique for all further fitting requirements. For example, the parametric bootstrap calculations of Chapter III rely on this method (Equation II-10).

It is important to acknowledge that the model of times to detect/classify described above has the sole purpose (at least for the moment) of generating realistic detection/classification times and allowing for the efficient simulation of various free play test control rules in order to improve *future* ASW search OTs. That is, after the OT is over, this sort of model may be of little value in gaining insight into system specific performance (i.e., explaining the performance of the past). Rather, the myriad sources of data (acoustic recordings, sonar log books, searcher and target position reconstructions), which should be available after the OT, offers the best opportunity to examine system capabilities and develop refined models of system specific performance.¹⁹

¹⁹ Similar sentiments were expressed, somewhat more eloquently, in 1946 (Ref. II-1, page 34).

E. CONFIDENCE INTERVALS USING A PARAMETRIC BOOTSTRAP

At the end of Section B of this chapter, approximate confidence intervals were computed for various search measures using a nonparametric bootstrap technique. Given the arguments of Sections C and D, we may now compute “parametric bootstrap” estimates (Ref. II-9, page 53) of these confidence intervals by randomly drawing times (t_i 's) from the MLE-fitted gamma density function ($\alpha' = 1.66$ and $\beta' = 4.54$).²⁰ The confidence intervals computed in this way have the advantage, relative to the nonparametric bootstrap intervals, of including the information associated with the conduct of the OT that led to the general shape of the distribution (i.e., the chosen gamma distribution model). Using the data from Table II-1, Table II-6 compares the parametric (in boldface) and nonparametric bootstrap confidence intervals for three parameters of interest.

**Table II-6. Approximate Confidence Intervals (C.I.):
Parametric (in Boldface) and Nonparametric Bootstrap**

% C.I.	SR	MdSR	MSR
80	82.9 - 143.5	93.7 - 194.5	139.0 - 399.5
	83.5 - 145.0	95.6 - 161.1	141.4 - 327.2
90	77.2 - 158.3	85.0 - 221.1	125.1 - 544.3
	77.7 - 157.8	73.6 - 230.8	127.6 - 360.5
95	73.2 - 168.3	78.1 - 245.8	115.1 - 687.4
	73.4 - 173.3	73.6 - 230.8	116.5 - 390.1

For this data set, the parametric and nonparametric techniques appear to be in good agreement for the SR and MdSR measures.²¹ With respect to MSR, differences between techniques are observed at the higher end of the interval.

The parametric bootstrap percentile confidence interval method described above will be referred to and used in the latter sections of Chapter III. For this study, we

²⁰ As was true for the nonparametric bootstrap, 2,000 bootstrap samples of 13 were drawn and the various search measures were computed. Again, the approximate confidence intervals reported here are based on the percentile method.

²¹ The exception to this “good agreement” is the high end of the 80 percent MdSR confidence interval.

assumed that the times to detect/classify originated from a gamma distribution. Parametric bootstrap techniques use the structure of an assumed specific underlying distributional model. Hence, we chose the parametric bootstrap technique, vice the nonparametric bootstrap methodology, so as to include this additional information. Given such a construct, large-sample approximations based on the same parametric formulation could also be used to construct statistical confidence intervals. If one chose to reject the assumption of gamma-distributed times to detect/classify, nonparametric approaches, including the nonparametric bootstrap, offer other possible confidence interval approaches.

F. SIMULATION DESCRIPTION

Using the previously described gamma distribution model ($\alpha' = 1.66$ and $\beta' = 4.54$) for times to detect/classify, we can consider simulating a free-play search OT and examining various test control rules. We built such a simulation that, given a random draw of times to detect/classify, allows one to determine, for instance, for a test of a given length, the number of encounters that would be expected to occur.²² To each random time to detect/classify, a period of time to represent localization, attack, and repositioning is added. The cumulative sum of these times is kept track of until the defined number of test days is reached. In addition, test rules are embedded in the test control process. For example, for a 20-hour stopping rule and a 50 percent shrinkage rule, the first time drawn from the gamma distribution that is greater than 20 hours would be truncated at 20 hours and 2 hours for repositioning would be added. The second time to detection/classification drawn that is greater than 20 hours (during the same test period) would again be truncated (with the addition of repositioning time), but this time the area size to be searched on the next trial would be shrunk by 50 percent. Using the roughly linear relationship between area size and average time to detect/classify described earlier (Table II-2), the mean times to detect/classify would also be shrunk by 50 percent for this next random draw. This procedure is followed until the number of specified test days are used up and all trials that reach FINEX, either via a truncation or an encounter, are saved.

For this study, four stopping rules were examined. These stopping rules (12, 16, 20, and 24 hours) were chosen in the following way. First, as described earlier, we represented the times to detection/classification by a gamma distribution with $\alpha' = 1.66$

²² This simulation is run on a *Microsoft EXCEL™* spreadsheet.

and $\beta' = 4.54$. Given this representation of times to detect/classify, we computed a probability of 0.184 for the detection/classification occurring at a time greater than 12 hours. Similarly, one computes probabilities 0.088, 0.041, and 0.019 for times of 16, 20, and 24 hours, respectively. These rules could be generalized to other gamma by simply using these four probabilities to recompute the stopping rules. For example, for gamma-distributed times to detect/classify with $\alpha', \beta' = 1.5, 6.0$ (i.e., mean time to detect/classify = $\alpha'\beta' = 9.0$ hours), and the probabilities given above (0.184, 0.088, 0.041, 0.019), truncation times of 14.5, 19.6, 24.8, and 29.9 hours are calculated, respectively.

Next, preliminary studies (Ref. II-17), in which 10-day OTs were simulated, were initially used to explore these stopping rules (and the shrinkage rules). The goal of this "scoping study" was to assess the ability of these rules to lead to area shrinkage when the system performed worse (half as well) than expected (the nominal system performance, System A), yet not to shrink the area when nominal system performance was observed. Shrinking the area after the first observation of a 20-hour truncation, for the 10-day OT, led to frequent shrinkage when nominal system performance was assumed. Shrinking the area after the third observation of a 20-hour truncation, again for a 10-day OT, was not deemed to lead to enough shrinkages in the case of the system that performed at half the capability of the nominal system. In the case of nominal system performance, about 16 percent (17/107) of the simulated 10-day tests led to shrinkage when the shrinkage rule was invoked after the second 20-hour truncation. For the system that performed half as well as the nominal system (System B), using the observation of the second 20-hour truncation as the shrinkage rule led to 83 percent of the 10-day OTs being shrunk. This sort of "trial and error" approach was pursued during this preliminary study (for a 10-day OT) and led to the above-described choice of stopping and shrinkage rules for further examination.

As discussed in the Introductory section of this paper, achieving realism during operational tests is considered a high priority. To this end, we have previously recommended that measures be taken to ensure that representative levels of uncertainty be maintained during ASW search OTs. Further, we have suggested a goal of keeping the times between detection long enough, on average, such that the probability of a search lasting less than the 6 hours of a typical sonar watch is about one-half or less (Ref. II-3, page IV-10). This suggestion was meant to support tenable levels of crew uncertainty (vigilance, see Ref. II-17). For the gamma distribution that we used to represent the nominal system performance ($\alpha', \beta' = 1.66, 4.54$; i.e., mean time to detect/classify = 7.54), the corresponding probability of a detection/classification occurring within 6 hours was

0.49. The conclusion, with respect to realism as defined above, is that a system with a mean time to detect/classify of 7.54 hours (assuming gamma-distributed times to detect/classify as described and an 800 NM² box) is appropriate.

In order to guarantee that the shrinkage rules described above would not lead to an area so small that the above vigilance rule would be violated, we applied one "expansion" rule during this simulation. A five-point and six-point running average of times to detect/classify was continuously monitored during the simulation. If the six-point average went below 1.5 hours *or* the five-point average went below 1.0 hour, then the box for the next and successive searches of that test trial (assuming no further triggering of shrinkage or expansion rules) would be doubled in size.

The expansion rules were arrived at via a trial and error procedure, similar to that described for identifying the stopping rules. Again, this was accomplished during a preliminary study of a simulated 10-day OT (Ref. II-17). Two system performance levels were examined: half as good as nominal (System B) and twice as good as nominal (System C). The chosen expansion rules led to expansions of the area for 0 (0/107) and 95 (61/65) percent of the simulated 10-day OTs (with a 20-hour stopping rule) for Systems B and C, respectively.²³ In general, these expansion rules did not appear to be very important and are only briefly discussed in this paper.

The test control rules that we examined are not the only ones that one might choose, nor do they necessarily represent an optimum set. Rather, they were arrived at by a process of trial and error as described above. The simulation study reported in this document further explores the properties of this chosen set of test control rules.

Two thousand four hundred random draws from the above-described gamma distribution were prepared. This same set of random draws was used for each set of test control rules that were examined in order to remove any variance resulting from the finite size of the draw. This number of draws turned out to be enough to allow for at least 100 simulated OTs under all of the various test control rules that were examined. A total of 96 different test situations were examined. In each case, 100 trials (or simulated OTs) were conducted.

²³ Although not reported on here, several other expansion rules were investigated including the use of running medians, different threshold times, and different expansion amounts (50 percent versus 100 percent).

Table II-7 delineates the various test situations that were investigated. In all cases, the time for repositioning was set at 2 hours and the initial area size to be searched was 800 NM². These 48 conditions ($2 \times 3 \times 4 \times 2$) were examined for our nominal 1994 system (Tables II-1 and II-2, average time to detect/classify = 7.54 hours) and for a system that “performed” half as well, with an average time to detect/classify = 15.08 hours.²⁴ Thus, a total of 96 (2×48) test situations were examined.

Table II-7. Test Situations That Were Simulated

Test Length (Days)	Localization and Attack Time (Hr)	Stopping Rule (Truncation Time - Hr)	Shrinkage Rule (%)
4 and 8	2, 4, and 8	12, 16, 20, 24	25 and 50

Figure II-9 presents a schematic that depicts the inputs, outputs, operations, and feedback loops (shown in red text) associated with this simulation (as described above).

Table II-8 shows the first 8-day trial, for a system with a 7.54-hour average time to detect/classify, with an assumed average localization and attack time of 4 hours, and using a stopping rule of 16 hours and a shrinkage rule of 25 percent. For this particular trial, 15 events were simulated within 8 days. Note that 6 hours (4 for localization and attack and 2 for repositioning) were added to each time to detect/classify that was less than 16 hours to generate the time of the encounter and reposition. Thirteen of these 15 events resulted in an encounter. The two events in which the random draw exceeded 16, the red font in Table II-8, were truncated at 16 hours and two hours for repositioning was added. After the second truncation, event 7, the area size was shrunk by 25 percent to 600 NM² and the random draws were shrunk by an equal amount to generate the new times to detect/classify (blue font in Table II-8).

²⁴ This was accomplished by simply doubling the 2,400 random draw values described earlier.

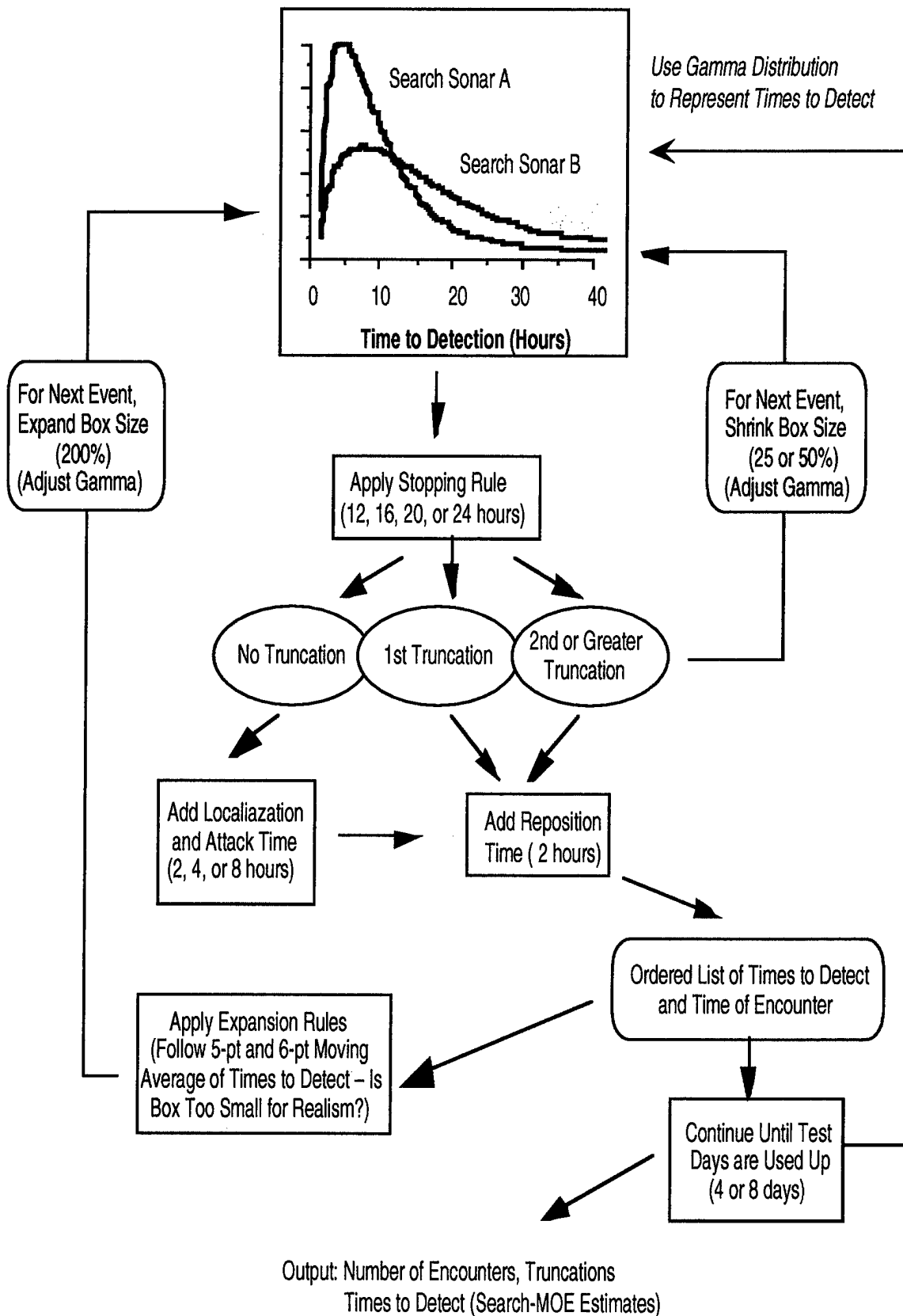


Figure II-9. EXCEL™ Spreadsheet Macro-Based OT Simulation Schematic

Table II-8. Example of One 8-Day Trial

Event Number	Random Draw	Time to Detect/Classify (Hr)	Time of Encounter and Reposition (Hr)	Cumulative Number of Days	Area Size (NM ²)
1	3.57	3.57	9.57	0.40	800
2	4.02	4.02	10.02	0.82	800
3	29.51	16.00	18.00	1.57	800
4	4.68	4.68	10.68	2.01	800
5	2.95	2.95	8.95	2.38	800
6	7.37	7.37	13.37	2.94	800
7	17.07	16.00	18.00	3.69	800
8	14.92	11.19	17.19	4.41	600
9	7.60	5.70	11.70	4.90	600
10	4.26	3.20	9.20	5.28	600
11	4.20	3.15	9.15	5.66	600
12	15.78	11.84	17.84	6.40	600
13	3.89	2.92	8.92	6.77	600
14	11.20	8.40	14.40	7.37	600
15	10.35	7.76	13.76	7.95	600
NC ^a	8.47	6.35	12.35	>8	600

^a NC = Not completed.

The results, or output of these simulations, include, for each of the 100 trials of a given test situation, estimates of the average time to detect/classify, the final area size being searched (i.e., at the end of the simulated OT), SR, MdSR, and MSR. These results – in particular tables, that list the frequency of occurrence of various values for each measure (i.e., data appropriate for histograms) – are presented in Appendix B. The average “observed” times, that is, the values that include truncated observations resulting from test stopping rules, are also reported in Appendix B. Similarly, the *observed values* of SR, MdSR, and MSR are reported. Chapter III provides an analysis of the results of these simulations.

REFERENCES

- II-1. *Search and Screening*, OEG Report No. 56, For the Chief of Naval Operations, 1946.
- II-2. *Manual for the Operations Analysis of Deep Ocean Search*, Daniel H. Wagner, Associates, 25 March 1971.
- II-3. *Operational Test and Evaluation (OT&E) Concepts for Attack Submarines*, IDA Paper P-2843, 8 November 1993, SECRET, pages IV-2 to IV-11.
- II-4. *Description of CARIB SHIELD Go-Fast Detection Model*, Joint Interagency Task Force-East Memorandum, 29 January 1997.
- II-5. *Improving Transit Zone Maritime Operations*, IDA Document D-1908, 25 November 1996.
- II-6. "Secure Sweep Width as a Measure of Detection Effectiveness", Daniel H. Wagner, Associates, *U.S. Navy Journal of Underwater Acoustics*, Volume 19, Number 2, April 1969.
- II-7. *Submarine-Versus-Submarine Secure Sweep Width Manual*, Daniel H. Wagner, Associates, 17 December 1964.
- II-8. *Review of the New Attack Submarine (NSSN) Early Operational Assessment (EOA)*, IDA Paper P-3071, 15 August 1995, pages II-43 and II-44.
- II-9. *Monographs on Statistics and Applied Probability 57: An Introduction to the Bootstrap*, B. Efron and R. J. Tibshirani, Chapman and Hall, 1993.
- II-10. *Computer Intensive Statistical Methods: Validation, Model Selection, and the Bootstrap*, J. S. Urban Hjorth, Chapman and Hall, 1994.
- II-11. *Computer Intensive Methods for Testing Hypotheses: An Introduction*, E. W. Noreen, John Wiley and Sons, 1989.
- II-12. *Modern Probability Theory and Its Applications*, E. Parzen, John Wiley & Sons, Inc., 1960, page 261.
- II-13. *Continuous Univariate Distributions*, Volume 1, Second Edition, N. Johnson, S. Kotz, and N. Balakrishnan, John Wiley & Sons, Inc., 1994, page 552.
- II-14. *Statistical Distributions*, Second Edition, M. Evans, N. Hastings, and B. Peacock, John Wiley & Sons, Inc., 1993, page 75.
- II-15. *Univariate Discrete Distributions*, Second Edition, N. Johnson, S. Kotz, and A. Kemp, John Wiley & Sons, Inc., 1992, page 59.
- II-16. Personal Communication, Professor Donald Gaver, Naval Postgraduate School, November 1996.
- II-17. *Planning Issues for Submarine Warfare Systems Operational Test and Evaluation*, IDA Briefing for DOT&E and COMOPTEVFOR, 31 May 1996.

- II-18. *Signal Detection Theory and Psychophysics*, D. M. Green and J. A. Swets, Peninsula Publishing, 1966, page 332.

CHAPTER III

RESULTS AND ANALYSES

III. RESULTS AND ANALYSES

This chapter provides an analysis of the results of the 96 sonar search OTs that were simulated. This analysis focuses on an examination of the impact of various test control rules. In particular, the impact of these truncation and shrinkage rules on the number of encounters obtained (per simulated OT) and the value and variance of the search measures of effectiveness (SR, MdSR, and MSR) estimated from these simulated OTs is investigated.

We begin by describing the results of a nominal run. Recall, a "run" is defined as 100 trials of a given test situation. A test "situation" is defined by the various test conduct initial conditions (e.g., number of days, area size at start, time spent repositioning) and test control rules (e.g., stopping time, shrinkage percentage).¹ A "trial" corresponds to one simulated OT of a given length. A given trial may have, for example, 15 events in 8 days, where 12 of the events ended with an encounter and 3 ended with an OTD-directed truncation.

A. A NOMINAL RUN: 8-DAY OT WITH 20-HOUR STOPPING RULE AND 25 PERCENT SHRINKAGE

This section reports the results for a nominal run. The goal of this section is to describe the type of information available from a given run. Table III-1 presents the initial conditions and test control rules that were associated with this nominal run. Note that for all runs described in this report the initial area size was 800 NM² and the time for repositioning after an encounter or truncation was two hours.²

We define the following shorthand notation to identify this particular run: {A|8|4|20|25}. The "A" corresponds to a sensor with an average time to detect/classify of 7.54 hours, the "8" refers to the number of test days simulated, the "4" identifies the assumed average localization and attack time, the "20" represents the stopping rule, and the "25" is the shrinkage percentage. This notation will be used occasionally in this paper to identify particular runs.

¹ See Appendix B, Table B-1.

² See Chapter II for a description of the expansion rules.

Table III-1. Test Situation Parameters for Nominal Run

Test Condition / Test Control Rule	Value
System Performance: Average Time to Detect/Classify	7.54 hours
Test Days	8
Localization and Attack Time	4 hours
Stopping Time	20 hours
Shrinkage Percentage	25 %

Figure III-1 presents a histogram of the number of events that were taken to completion (i.e., resulted in an encounter) and the total number of events (i.e., those that ended with an encounter or a truncation). Figure III-2 presents a histogram that describes the final area sizes being searched. Figures III-3 through III-6 provide histograms of the various search measures (i.e., average time to detect/classify, SR, MdSR, and MSR, respectively).

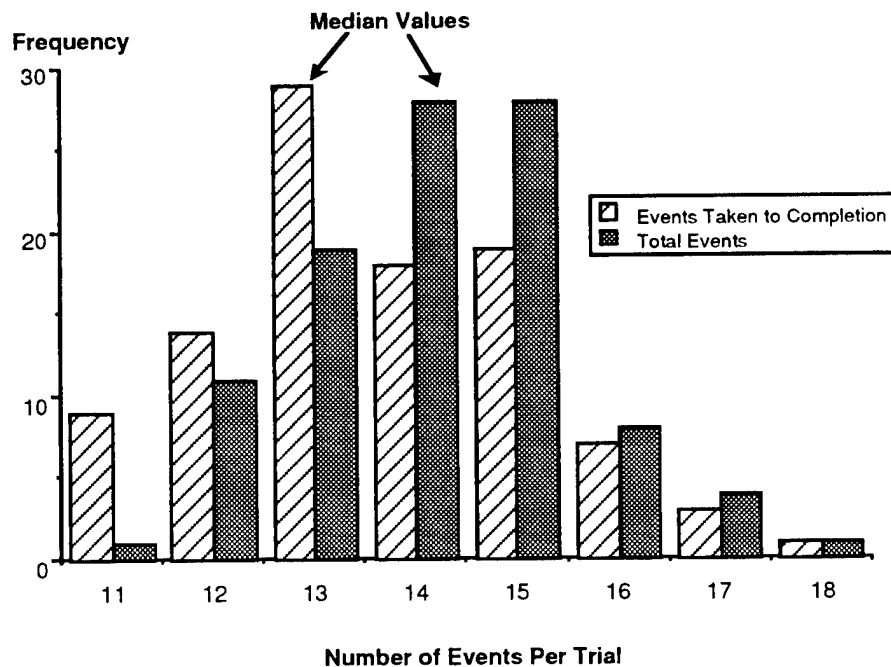


Figure III-1. Events Per Simulated OT for Nominal Run

For this particular 8-day run, the median number of events was 14 with a median number of encounters (events taken to completion) of 13. The total number of events ranges from 11 to 18 as do the total number of encounters.

Of 100 trials started with an area size of 800 NM², eight were shrunk by 25 percent to 600 NM² by the end of the simulated OT and one was shrunk twice by 25 percent to 450 NM². See Figure III-2.

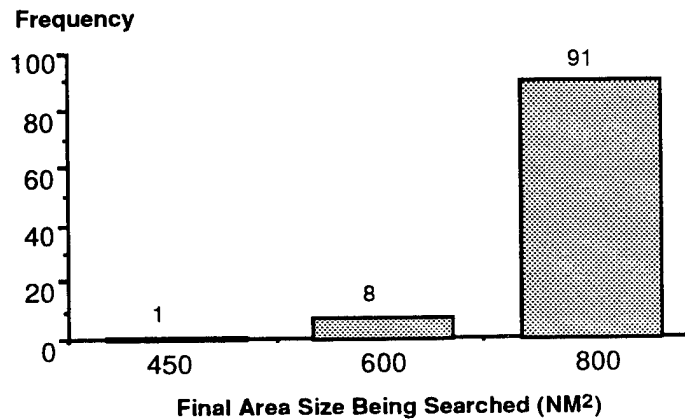


Figure III-2. Area Size at the Completion of the Simulated OT

The median value of the average time to detect/classify for a trial was about 8 hours (Figure III-3). Note that the impact of OTD-forced truncations (censoring) is to shorten the “right tail” of the distribution.³ For this run, only one out of 100 simulated OTs had an average search duration (time to detect/classify) less than the 6-hours of our typical sonar watch.

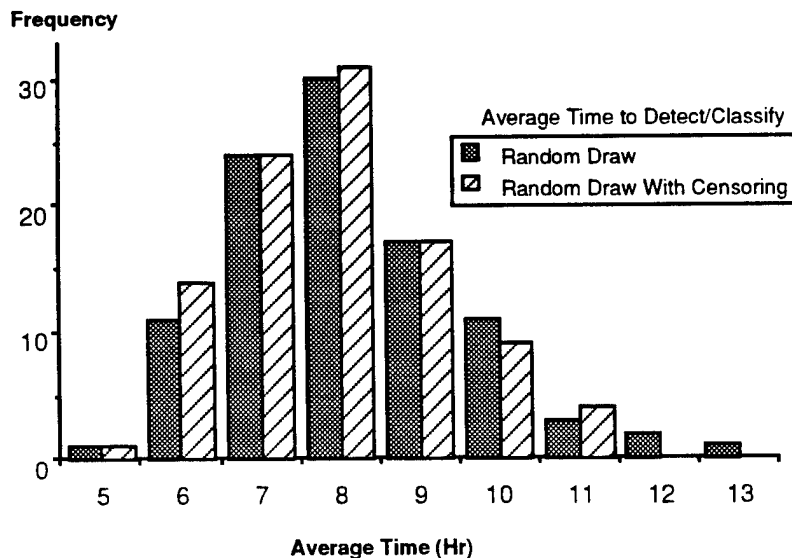


Figure III-3. Histogram of Average Time to Detect/Classify Normalized to 800 NM²

³ The cross-hatched bars in Figure III-3 labeled “random draw with censoring” correspond to the frequency of average times to detect/classify, for a given simulated OT, in which for the events that ended with a truncation, the truncation time (stopping rule) was used as if it were a detection/classification time.

Figure III-4 presents a histogram of search rate (SR), where SR is defined as in Chapter II. SR values computed from the actual (normalized to 800 NM²) random draws and from the values obtained after the OTD-forced truncations are presented. The impact of the truncations can be seen in Figure III-4 as somewhat less mass in the distribution of SR for smaller values (less than 90 NM²/Hr). In both the “random draw” and “random draw with censoring” case, the median value of the SRs falls in the 110 NM²/Hr bin. This value is in good agreement with area size divided by the expected time to detect/classify ($\alpha \times \beta$) 7.54 hours ($800/7.54 = 106$ NM²/Hr).

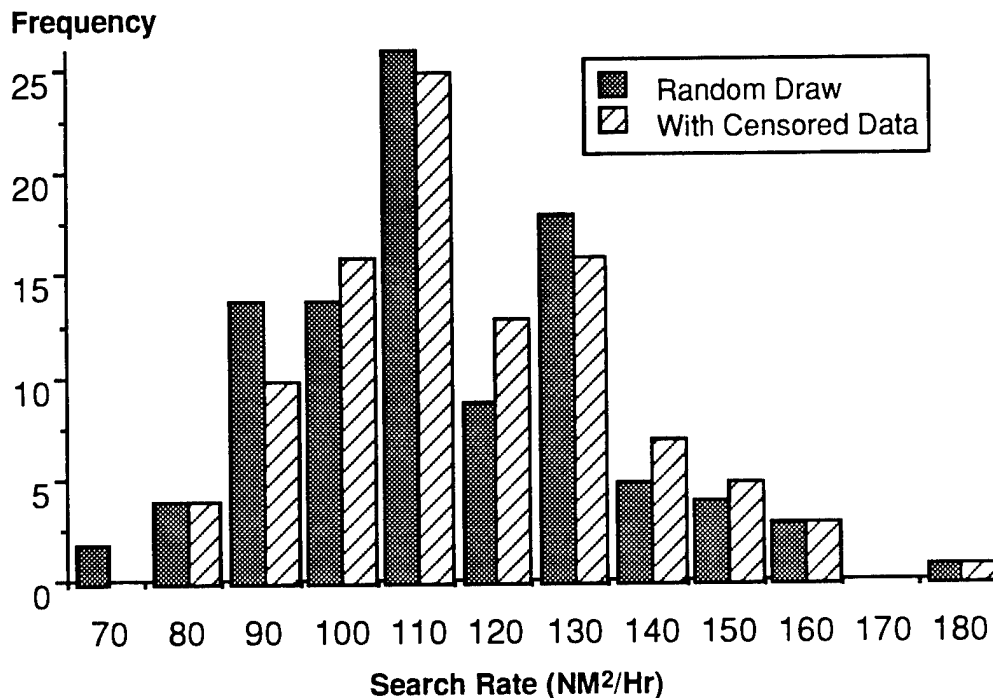


Figure III-4. Histogram of Search Rate (SR) Estimates for Nominal Run

Figure III-5 presents the histogram for the search measure median search rate (MdSR). Estimates of MdSR were never impacted by the OTD-forced truncations, since in no case (i.e., for none of the 9,600 trials) did the number of truncations exceed one-half of the total number of events. The median value of MdSR is about 130 NM²/Hr.

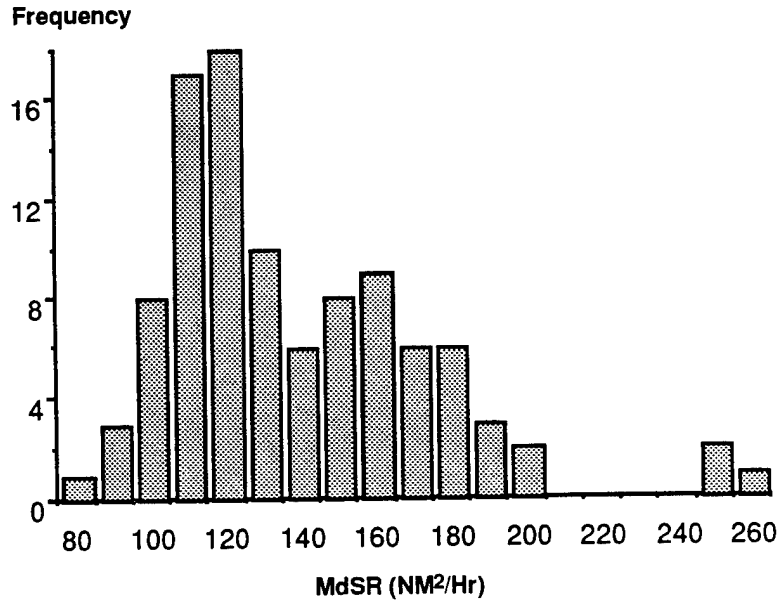


Figure III-5. Histogram of Median Search Rate Estimates for Nominal Run

Finally, Figure III-6 shows the histograms for mean search rate (MSR). As was the case with SR, the truncations shift the distribution slightly to the right (higher values). The median value of MSR, for both cases shown in Figure III-6, is about 240 NM²/Hr.

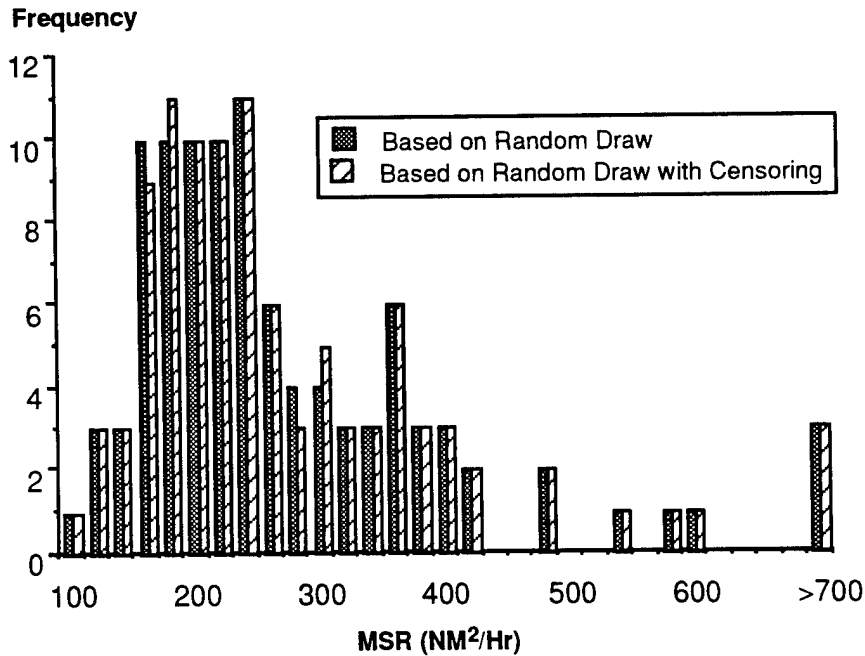


Figure III-6. Histogram of Mean Search Rate Estimates for Nominal Run

B. IMPACT OF TEST CONDITIONS AND TEST CONTROL RULES ON THE NUMBER OF EVENTS PER SIMULATED OT

This section examines the number of events that resulted from the various test conditions and test control rules.

1. Impact of Test Conditions

Figure III-7 shows the impact of test duration on the number of test events. The test condition and control rules described in the last section, {A|8|4|20|25}, are compared to the same conditions and rules but for only a 4-day test duration, that is, {A|4|4|20|25}, in Figure III-7. Figure III-7 plots the median value (based on 100 trials) for the number of events taken to completion and the median value for the total number of events. The "error" bars in Figure III-7 correspond to the 80 percent interval of the computed distribution.⁴ For this case and, in general, the relationship between test duration and the number of events is roughly linear. That is, doubling the test duration from 4 to 8 days leads to a doubling in the expected number of total events from 7 to 14. (Exceptions to this linearity are discussed later in this section.)

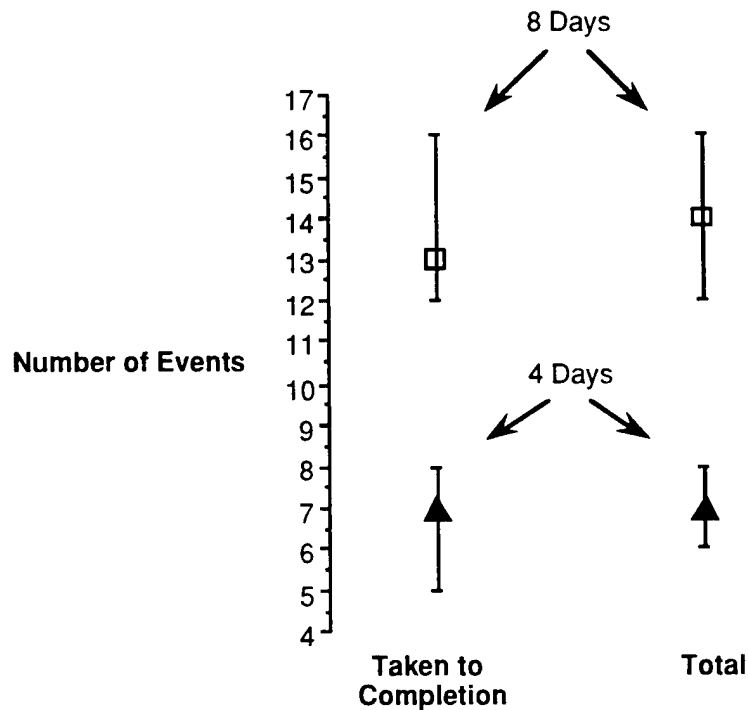


Figure III-7. Impact of Test Duration on Number of Events

⁴ That is, the lower bar corresponds to the 10th percentile value for the 100 trials and the upper bar corresponds to the 90th percentile value of the 100 trials.

Figure III-8 portrays the impact of increasing the average time for localization and attack from 2 to 8 hours.⁵ Figure III-8 has a format similar to Figure III-7 (i.e., median values and 80 percent intervals are shown). As expected, the number of test events decreases as the average number of hours assumed for localization and attack increases. This relationship appears to be roughly linear with a somewhat more negative slope for the longer test duration. (The dashed lines of Figure III-8 correspond to “least-squares” linear fits.)

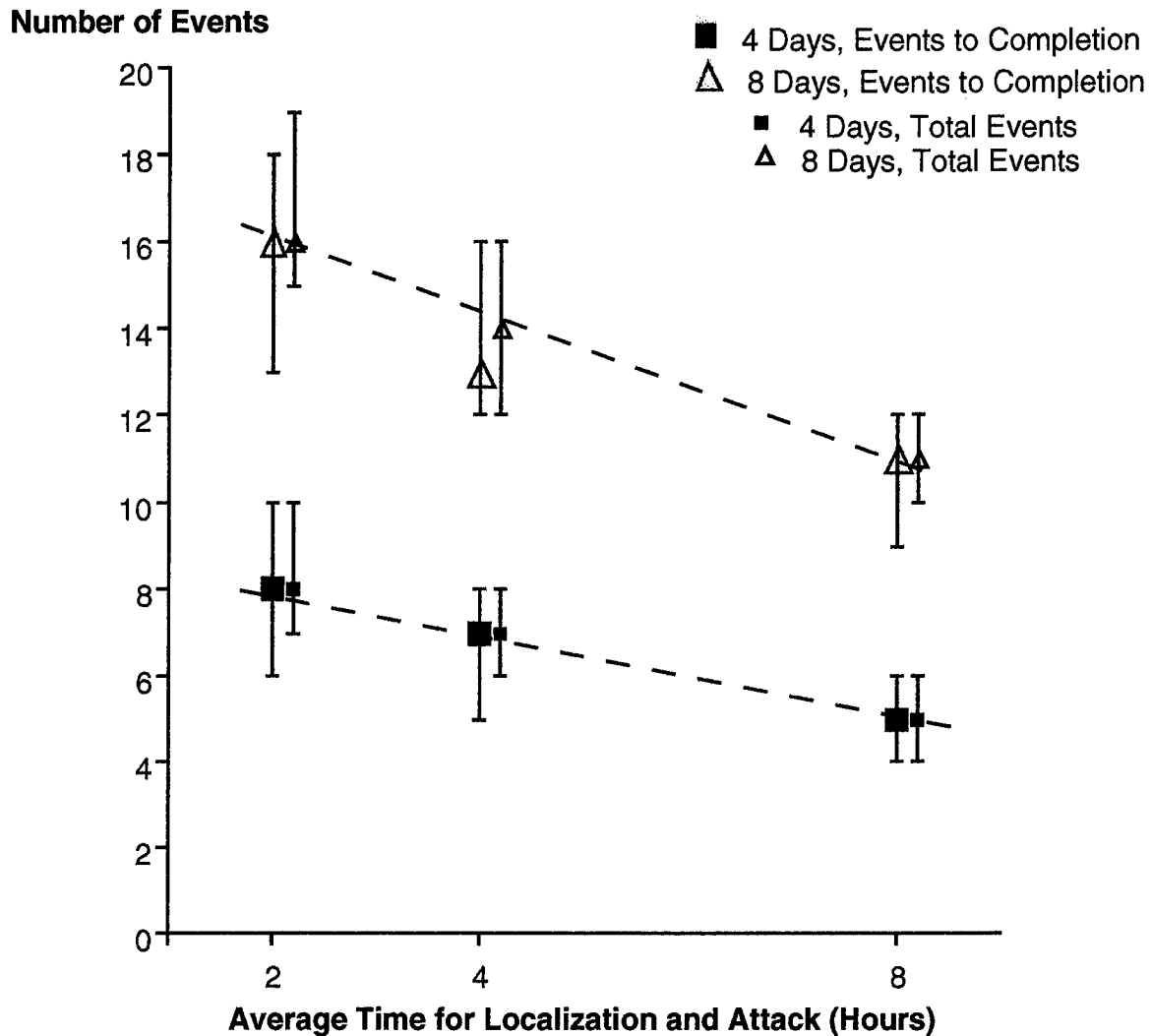


Figure III-8. Impact of Average Time for Localization and Attack on Number of Events

⁵ Figure III-8 examines the impact of the systematic variation of the assumed localization and attack time. Figure III-8 compares the results of the following six runs: {A|8|2|20|25}, {A|8|4|20|25}, {A|8|8|20|25}, {A|4|2|20|25}, {A|4|4|20|25}, and {A|4|8|20|25}.

We now consider the impact of testing a system that is nominally half as good – perhaps the environment or target is twice as difficult – as the one we have previously assumed. That is, the times to detect/classify for this poorer system (“System B”) are, on average, twice as long as the times associated with the nominal system (“System A”). Recall (Chapter II, page II-19) that System A was based on past observations and for the test conditions considered had an average time to detect/classify of 7.54 hours. Thus, System B, for the same set of test conditions, is simulated by using an average time to detect/classify of 15.08 hours.

Figure III-9 presents the results of our simulations for System A, in blue, and System B, in red.⁶ Figure III-9 employs a format similar to the two previous figures.⁷ A few conclusions are evident from Figure III-9. First, the poorer system, being tested in an 800 NM² box, leads to fewer events. However, halving the system performance (i.e., doubling the times to detect/classify) did not halve the number of events. For example, for an assumption of 2 hours (on average) for localization and attack and 8 days of testing, System A had median values of 16 for events taken to completion and total events, whereas System B had median values of 10 and 13, respectively. The same trend is observed for the other assumptions of localization and attack time and for the 4-day test duration as well. In part, this relative test efficiency (i.e., the event sample size does not decrease as fast as the system performance) is due to the 20-hour stopping rule, which truncated some of the longest events that would have “wasted OT time.”

A second feature of Figure III-9 is related to the magnitude of the differences between the events taken to completion and the total number of events (compare circles to triangles). For System A, the median value for events taken to completion (i.e., ending in an encounter) is generally equal to the median value for the total number of events. The exception is the 8-day, 4-hour localization/attack time case, for which the median value for the total number of events is 14 and the median value for events taken to completion is 13. As expected for System B, the 20-hour stopping rule is occasionally “triggered” and results in differences between the median values of events taken to completion and total events. For example, for the 8-day test and the 2-hour assumed localization/attack time case, the median value for the total number of events is 13 and the median value for events taken to completion is 10.

⁶ The results related to 4-day test simulations are shown with shaded circles or triangles and the 8-day test results are shown with open circles or triangles.

⁷ In fact, the points and error bars shown in blue in Figure III-9 (System A), correspond exactly to those of Figure III-8.

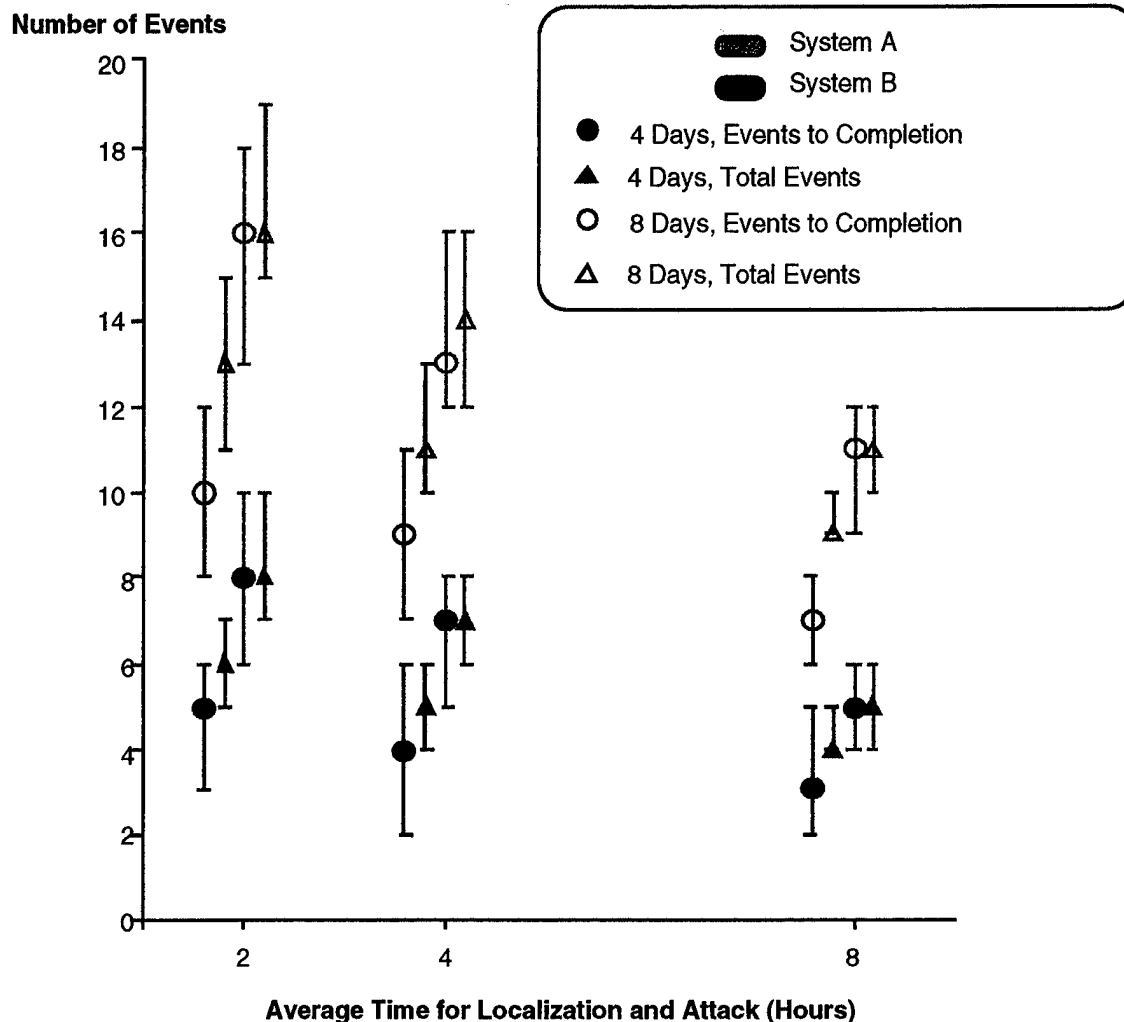


Figure III-9. Impact of Assumed System Performance on Number of Events

If two or more events were truncated during a trial, the test control rules caused the area size to be shrunk, in this case by 25 percent (from 800 NM² to 600 NM²). Figure III-10 shows the distributions of area sizes at the end of the simulated tests (all tests started at 800 NM²) for six conditions. As expected, the trials involving System B led to the employment of shrinkage rules much more often than the comparable trials involving System A. For instance, for the 4-day simulated OT, only 1, 3, and 1 of 100 System A trials led to shrinkage to a 600 NM² box, for the 2-, 4-, and 8-hour localization and attack assumptions, respectively. The comparable numbers for the System B simulations are 31, 21, and 25 of 100, respectively, with a few of those (3, 3, and 1) shrinking yet again to 450 NM². For the 8-day set of trials, the effect is more dramatic (Figure III-10). In the three 8-day, System B cases shown in Figure III-10, the median value of the final area

size searched is 600 NM². That is, the shrinkage rule described here (i.e., two 20-hour truncations lead to a 25 percent shrinkage) is usually employed in the case where the system performance is one-half of what was expected (System B).

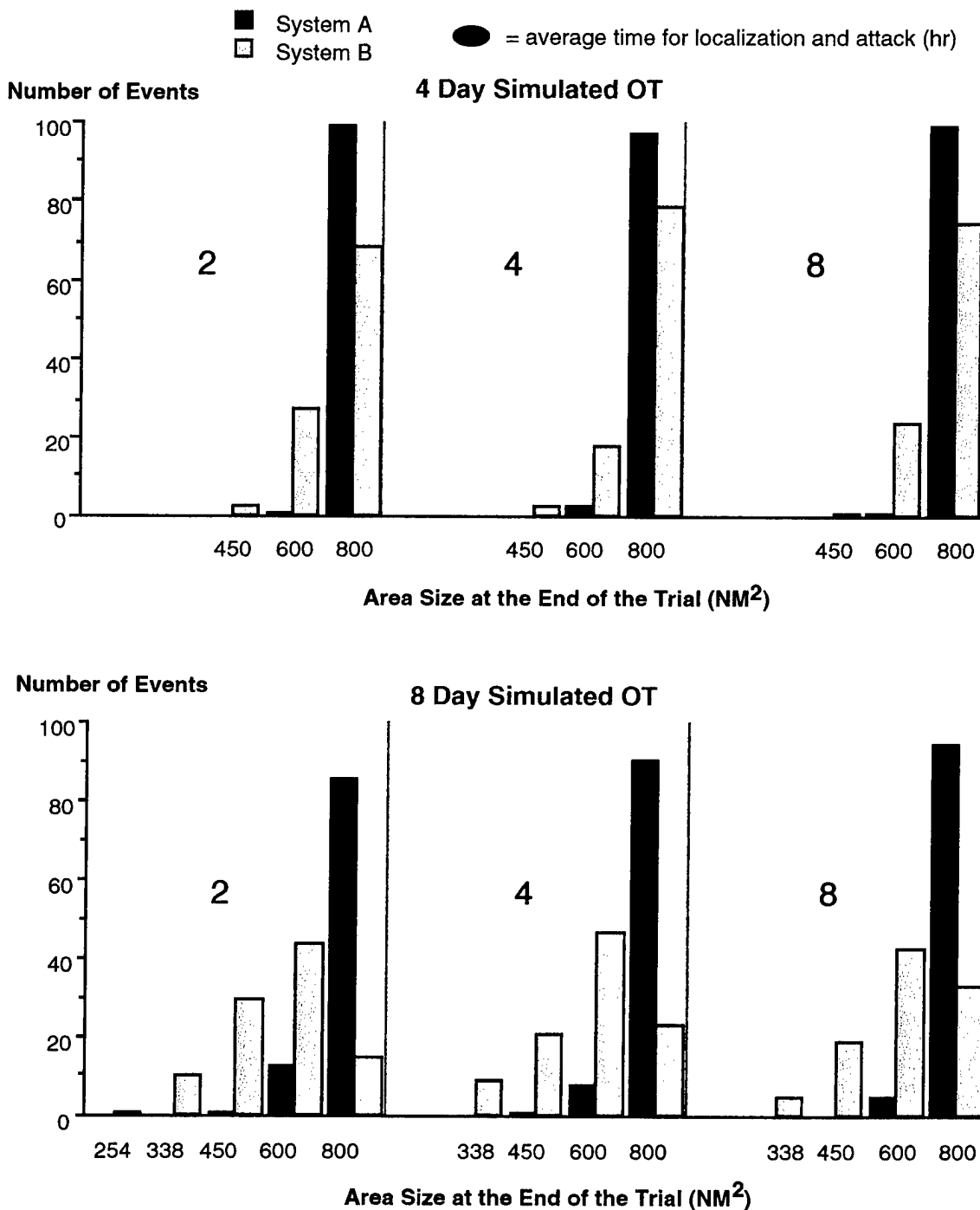


Figure III-10. Employment of Shrinkage Rule: Distribution of Areas Sizes at the End of Simulated OT

2. Impact of Test Control Rules

This section focuses on the impact of the chosen stopping/shrinkage rules (12, 16, 20, or 24 hours and 25 or 50 percent shrinkage) on the number of events expected. Figures III-11 and III-12 show the effect of differing stopping rules on the median value of the number of events taken to completion and the median value of the total number of events, respectively. (Both of these figures result from the usage of a 25-percent shrinkage rule.)

The stopping rules can increase the number of events per trial (simulated OT) in two ways. First, events that might be very long (e.g., > one day) are truncated, saving some of the post-truncation search time for the next event. Second, if the stopping rule is invoked twice during one trial, the area size is shrunk by some specified amount (25 percent in this case), and the follow-on times to detect/classify are therefore shorter, on average. Taken over enough test days, these stopping rules will increase the number of events.

With respect to the median value of the number of events taken to completion (Figure III-11), it is seen that for 4-day tests, differences in stopping rules have no impact.⁸ For the nominal system (System A), there is only marginal impact at the 8-day mark. However, for the system that performs poorer than expected (System B), at 8 days, the shorter test control stopping rules, 12 and 16 hours, result in a larger median value. This trend is magnified when the median value of the total number of events per trial is considered (Figure III-12). For example, in the case of an 8-day test of System B (with a 4-hour localization/attack time), the 12-hour rule results in a median value of total number of events per trial of 15, whereas the 24-hour rule leads to a median value of 10 (50 percent larger). Even for the shorter 4-day test, the results for System B vary as a function of stopping rule from 6 to 4, 7 to 5, and 8 to 5, for the three assumed average times for localization and attack – 2, 4, and 8, respectively.

We conclude that shorter stopping rule times can increase the number of events (and events to completion) for longer test periods and/or when the system (including the target and environment) being tested is a significantly poorer detector/classifier than

⁸ Recall that the values reported in Figure III-11 correspond to the median values of the number of events taken to completion (from distributions reported in Appendix B). An examination of the actual distributions shows the small expected changes in the number of events taken to completion for the 4 day test case (given the usage of these test control rules).

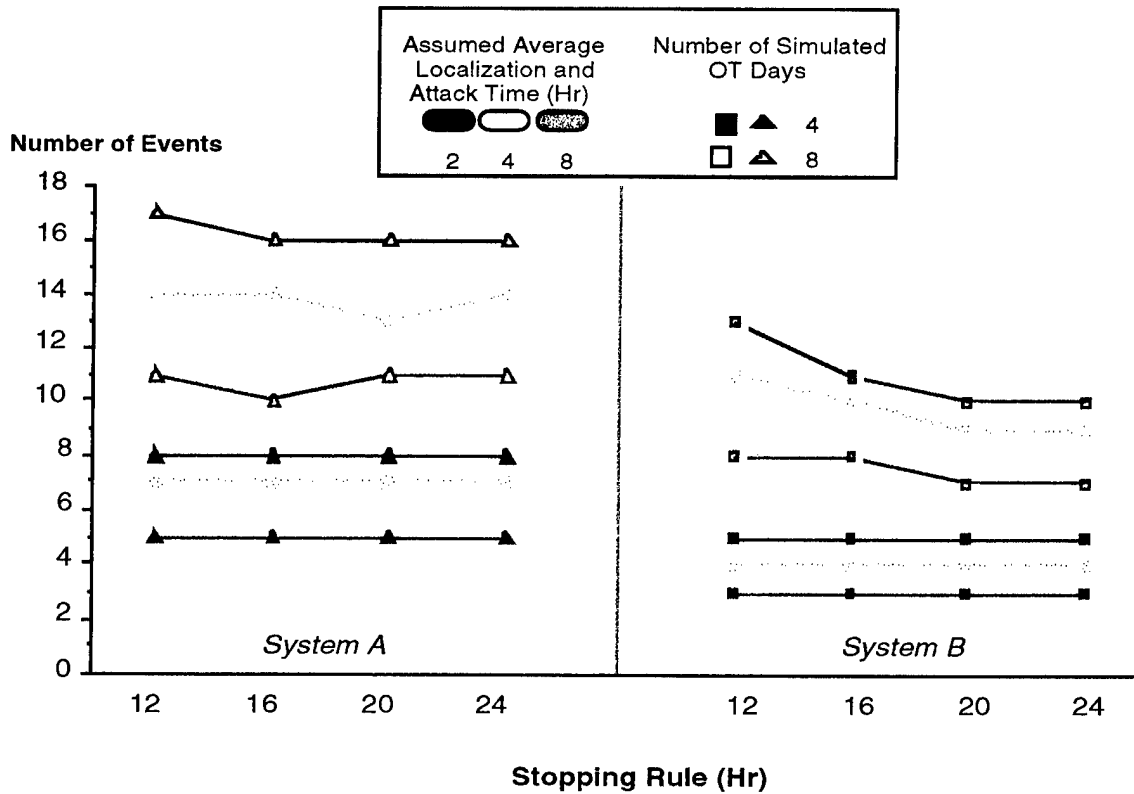


Figure III-11. Test Control Stopping Rules: Median Value of the Number of Events Taken to Completion

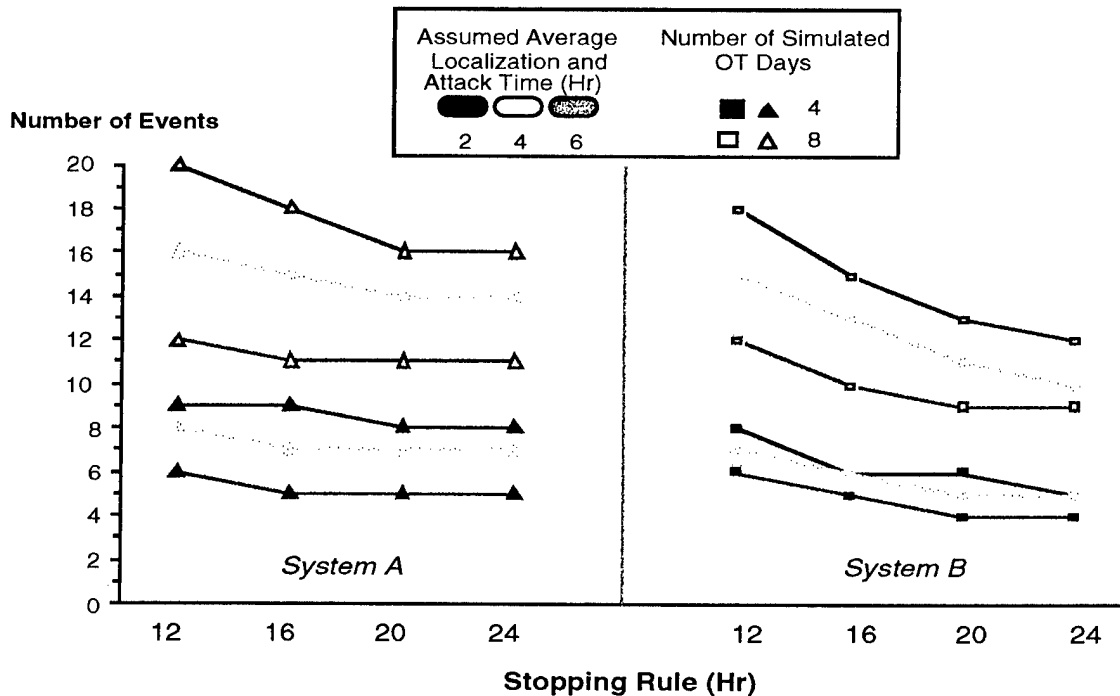


Figure III-12. Test Control Stopping Rules: Median Value of the Total Number of Events

initially expected (i.e., poorer than the system assumed when "sizing" the original search box).

Figure III-13 compares two test control shrinkage rules, 25 and 50 percent. The solid lines of this figure correspond to the median value for the number of events taken to completion (as always, for 100 trials) with the 25 percent shrinkage rule employed. *That is, the solid colored lines of Figure III-13 are identical to those of Figure III-11.* The "diamonds" and "stars" of Figure III-13 correspond to the values associated with the use of a 50 percent shrinkage rule. Figure III-14 is of the same format but presents the median values for the total number of events. That is, the solid lines of Figure III-14 correspond to the data of Figure III-12. The diamonds and stars of Figure III-14 correspond to the median values that result from a 50 percent shrinkage rule.

Comparing the 50 percent and 25 percent shrinkage rules results (Figures III-13 and III-14), we first note that the median values associated with the 50 percent rule trials are always greater than or equal to those of the 25 percent rule. This is because, when invoked, the 50 shrinkage percent rule leads to smaller areas to be searched and, hence, shorter times, on average, to detection/classification. Over a long enough period of test time, this results in more events taken to completion and more total events. There is little difference between the 25 and 50 percent shrinkage rule results for the 4-day test. Similarly, for 8-day tests of System A, the system that performs as expected, the 50 percent rule adds only 1 or 2 to the median value when the 12-hour stopping rule is employed. However, for the 8-day test of System B, the 50 percent shrinkage rule resulted in significantly more events taken to completion and total events. For example, for the 16-hour rule (System B, 2-hour average localization/attack time), the 50 percent rule resulted in a median value of 15 and the 25 percent rule resulted in a median value of 11. That is, for this case, a 36 percent increase in the median value of events taken to completion was caused by changing the shrinkage rule from 25 to 50 percent.

The impact of a 50 percent shrinkage rule, relative to a 25 percent rule, on the median value of total events can be seen in Figure III-14. The results are similar to those discussed above for the number of events taken to completion, albeit with a somewhat smaller impact. For instance, in the case of the 8-day test of System B with a 16-hour stopping rule and a 2-hour average time for localization and attack, the 50 percent shrinkage rule results in a median value of total events of 17 and the 25 percent rule results in a median value of 15.

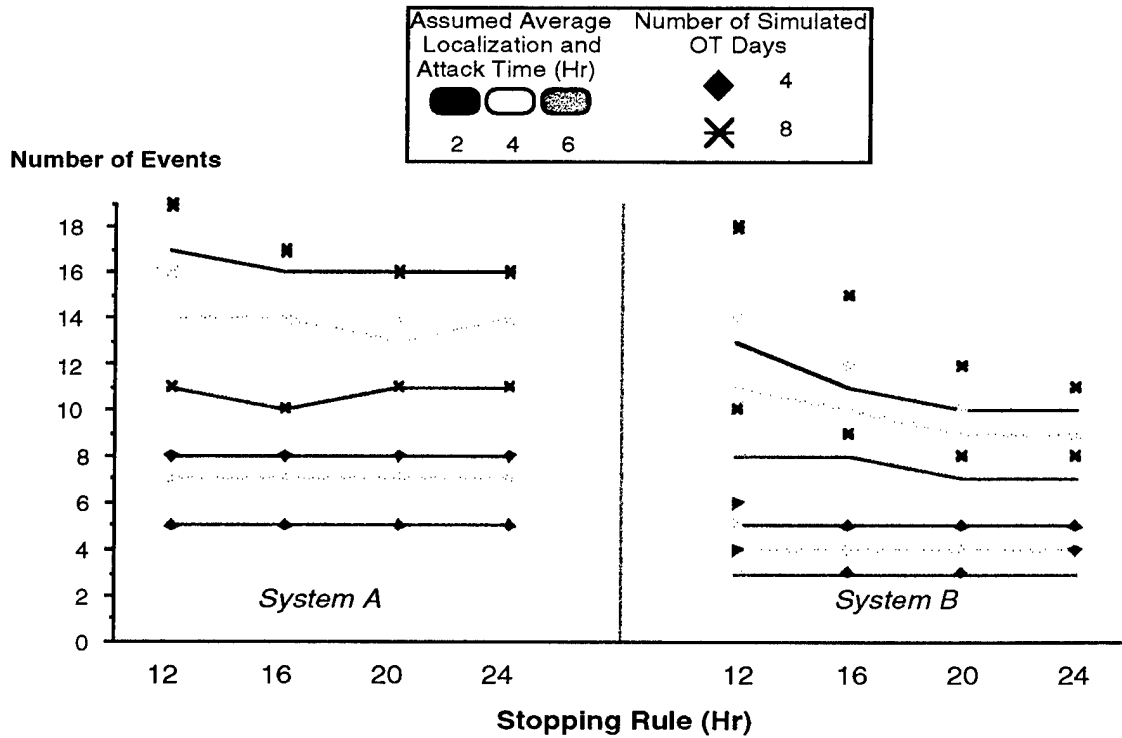


Figure III-13. Test Control Shrinkage Rules: Median Value of the Number of Events Taken to Completion

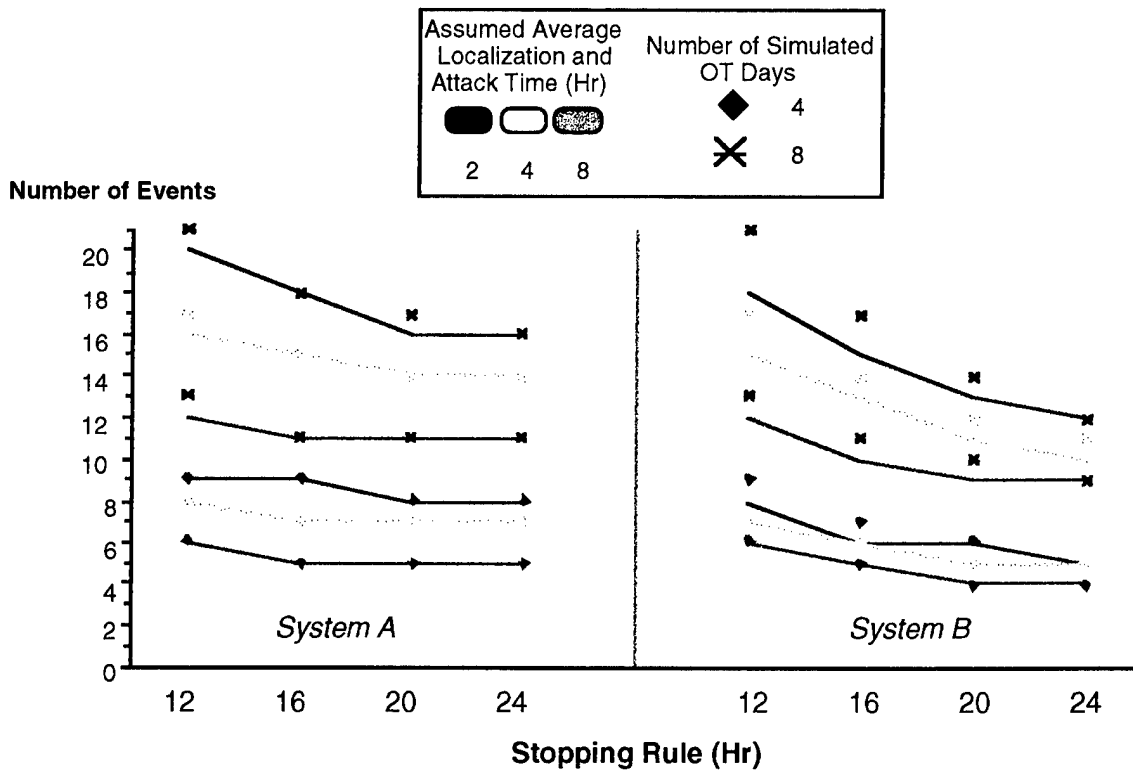
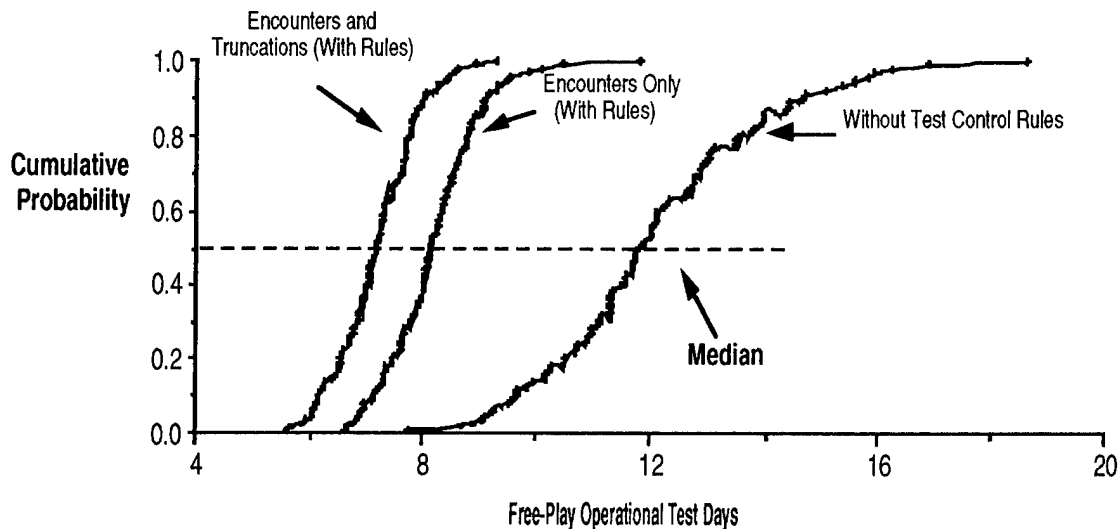


Figure III-14. Test Control Shrinkage Rules: Median Value of the Total Number of Events

Figures III-11 through III-14 also allow for a comparison of the median values of the number of events taken to completion or the median value of the number of total events as a function of the System being tested, A or B. As discussed earlier (Figure III-9), the test control rules (stopping time and/or shrinkage percent) tend to mitigate, by design, the effect of system performance on the number of events realized. For longer tests, for example, 8 days, even a system that performs half as well as expected can be tested with these rules such that about the same number of events is realized as would have been if the system had performed as expected. For instance, for the 16-hour stopping rule and 50 percent shrinkage rule (with a 4-hour average time for localization and attack), the median values for events taken to completion and total events are 14 and 15, respectively, for System A. For System B, the median values are 12 and 14, respectively (within 15 percent of the System A values).

We also investigated the potential for time savings resulting from the use of test control rules in a free-play OT. For this examination, we simulated an event-terminated, rather than time-terminated, free-play OT. We considered a 15-encounter (i.e., events taken to completion) OT in which System B, the poorer performer, was tested without test control rules. We also simulated the same situation with the 16-hour stopping rule and the 50 percent shrinkage rule. In both cases, 100 trials were run (using the same initial set of random draws) and 4 hours were assumed for the average time to localize, attack, and reposition. Figure III-15 shows the cumulative probability of completing such a 15-encounter OT as a function of test days. Without the test control rules (curve shown in black), it takes between 8 and 18 days, with a median value of about 12 days, to complete this free-play OT. By using the 16-hour/50 percent shrinkage rule (curve shown in red), this 15-encounter OT of System B takes between 7 and 12 days, with a median value of about 8 days. That is, using the median values for comparison, these specific test rules allow this OT of System B to be completed in 33 percent less time. Figure III-15 also shows the cumulative probability of completing a 15-event (encounters plus truncations) OT with the test control rules (curve shown in blue). This OT is completed in between 6 and 9 days, with a median value of about 7 days.

Of course, triggering the test control rules too often, that is, truncating too many events or shrinking the area size by too much, can lead to unwanted effects. If the area is shrunk too much, the times to detect/classify may become unrealistically short. Recall (Chapter II) that our test control rules (and, hence, our simulation) contained an "expansion" rule. If ever the running six-point average of the times to detect/classify



**Figure III-15. Time Savings Due to the Use of Test Control Rules:
Number of Days Required for a 15-Event OT of System B**

went below 1.5 hours or the running five-point average went below 1.0 hour, the expansion rule called for doubling the size of the box.

For the 96 runs (test situations) that we examined, only 12 led to the triggering of this expansion rule. Triggering the expansion rule is an indication that, for at least a portion of the test, the times to detect/classify were unrealistically short. Eleven of the 12 runs in which the expansion rule was invoked involved the 50 percent shrinkage rule and 9 of the 12 runs involved the 12-hour stopping rule. The combination of the 12-hour stopping rule and 50 percent shrinkage rule accounted for seven of the 12 runs that invoked the expansion rule.

Table III-2 lists the runs in which the expansion rule was invoked. Table III-2 also lists the number of trials (out of 100) in which the expansion rule was triggered for each run in which it was triggered and the (approximate) average time to detect/classify that was realized for the median trial of that run. Recall, the average time to detect/classify for System A in an 800 NM² box should be 7.54 hours. In situations in which the rules were rarely invoked, for example, when using the 24-hour stopping rule, the average time to detect/classify for the median trial (no truncations) for System A (8-day test, 8-hour average localization and attack time and 50 percent shrinkage rule) was 7.45 hours (close to the nominal value of 7.54 hours). The comparable run (median trial with one truncation) for System B was 10.75 hours. Recall, System B starts the test in an 800 NM² area with an average time to detect/classify of 15.08 hours. Of course, once the

Table III-2. Test Situations in Which the Expansion Rule Was Invoked

System	Test Days	L&A Time (Hr) ^a	Stopping Rule (Hr) / Shrinkage Rule (%)	# of Trials With Expansion	Average Time to Detect/Classify for Median Trial (Hr)	Approximate Probability of Detect/Classify Within 6 Hours
A	4	2	12 / 50	1	6.25	0.58
A	8	8	12 / 50	3	5.27	0.67
A	8	4	12 / 50	2	5.13	0.68
A	8	2	12 / 25	1	4.82	0.71
A	8	2	12 / 50	10	4.63	0.73
A	8	2	16 / 50	2	6.24	0.58
B	8	8	12 / 50	1	5.00	0.69
B	8	8	16 / 50	1	7.33	0.51
B	8	4	12 / 50	4	4.71	0.72
B	8	2	12 / 50	9	4.33	0.76
B	8	2	16 / 50	1	6.40	0.57
B	8	2	20 / 50	1	8.33	0.45

^a L&A = Localization and attack . The approximate average times to detect/classify for the median trial were computed as follows. First, the number of events taken to completion and truncations for the median trial was extracted from Appendix B. Next, the hours due to localization, attack, repositioning, and truncation were subtracted from 96 hours (the approximate length of the test). The remaining "search" hours were divided by the number of detections/classifications for the median trial.

50 percent shrinkage rule is triggered, these times to detect/classify will, on average, get 50 percent shorter. The average times discussed above, 7.54 and 7.45 hours for System A and 10.75 hours for System B, result from situations in which the stopping rules were rarely or never invoked, and represent points for comparison to the times shown in Table III-2. The runs shown in Table III-2 correspond to situations in which the shrinkage rule was invoked so often that the expansion rule was eventually triggered.

The approximate average times to detect/classify shown in Table III-2 for the 12-hour stopping/50 percent shrinkage rule, as expected, are shorter than the nominal (System A in 800 NM² area) time of 7.54 hours. The fact that the expansion rule was triggered, that is, several short times to detect/classify in a row were realized, and that the average time to detect/classify was found to be significantly less than the nominal value

suggests that at least some portion of this OT would have been conducted with unrealistic times to detection/classification.

Assuming a gamma distribution with $\alpha' = 1.66$ (our initial distributional model), and rescaling β' to the average times reported in Table III-2 (mean time/ $\alpha' = \beta'$), allows us to estimate, based on this new fitted gamma distribution, the probability of detection/classification occurring on a 6-hour sonar watch (that starts at COMEX). The last column of Table III-2 presents these probabilities. The 8-day test situations that involve the 12 hour stopping rule and the 50 percent shrinkage rule led to conditions in which we estimate the expected probability of detection within 6 hours for the median trial to be greater than our test realism rule-of-thumb described in Chapter II (“less than half a chance of a detection/classification within 6 hours”). For these situations, the probabilities of detect/classify within 6 hours for the median trial vary from 0.67 to 0.73 and between 0.69 and 0.76 for Systems A and B, respectively. For comparison, using the 24 hour stopping rule and 25 percent shrinkage rule over an 8-day test led to comparably computed probabilities for the median trial of between 0.47 and 0.50 and between 0.29 and 0.37 for Systems A and B, respectively.

We conclude that, although the 12-hour stopping/50 percent shrinkage rule offers the most events for a test of a given duration, it comes, sometimes, with a steep price – test realism. Therefore, for systems like A or B, we would want to avoid the combination of short stopping rules (e.g., 12 hours) and large shrinkage rules (e.g., 50 percent). On the other hand, stopping rules of 16, 20, and 24 hours with shrinkage rules of 25 percent or, in general, 50 percent appear satisfactory, with the 16-hour stopping rule offering real benefits with respect to sample size robustness to system performance in an 8-day test (compare System A and B in Figures III-13 and III-14).

A second potential problem with the employment of stopping rules is the effect of truncated events on estimates of search MOEs. This issue and others related to estimates of search MOEs are described in the next section.

C. IMPACT OF TEST CONDITIONS AND TEST CONTROL RULES ON ESTIMATES OF SEARCH MOES

Three search MOEs are examined in this section – SR, MdSR, and MSR. Chapter II (Equations 5a through 5c) provides definitions of these search-related MOEs. Importantly, for simulated trials in which events are truncated, the censored times, for example, 20 hours for the 20-hour stopping rule, can be used directly to estimate the various search-related MOEs.

Figure III-16 presents the median values and the 80 percent intervals of the three search MOEs that resulted from simulation (100 trials) with the 24-hour stopping rule and the 25 percent shrinkage rule.⁹ We note that the median values, represented by the solid triangles, do not vary much as a function of test duration or assumed localization and attack time.

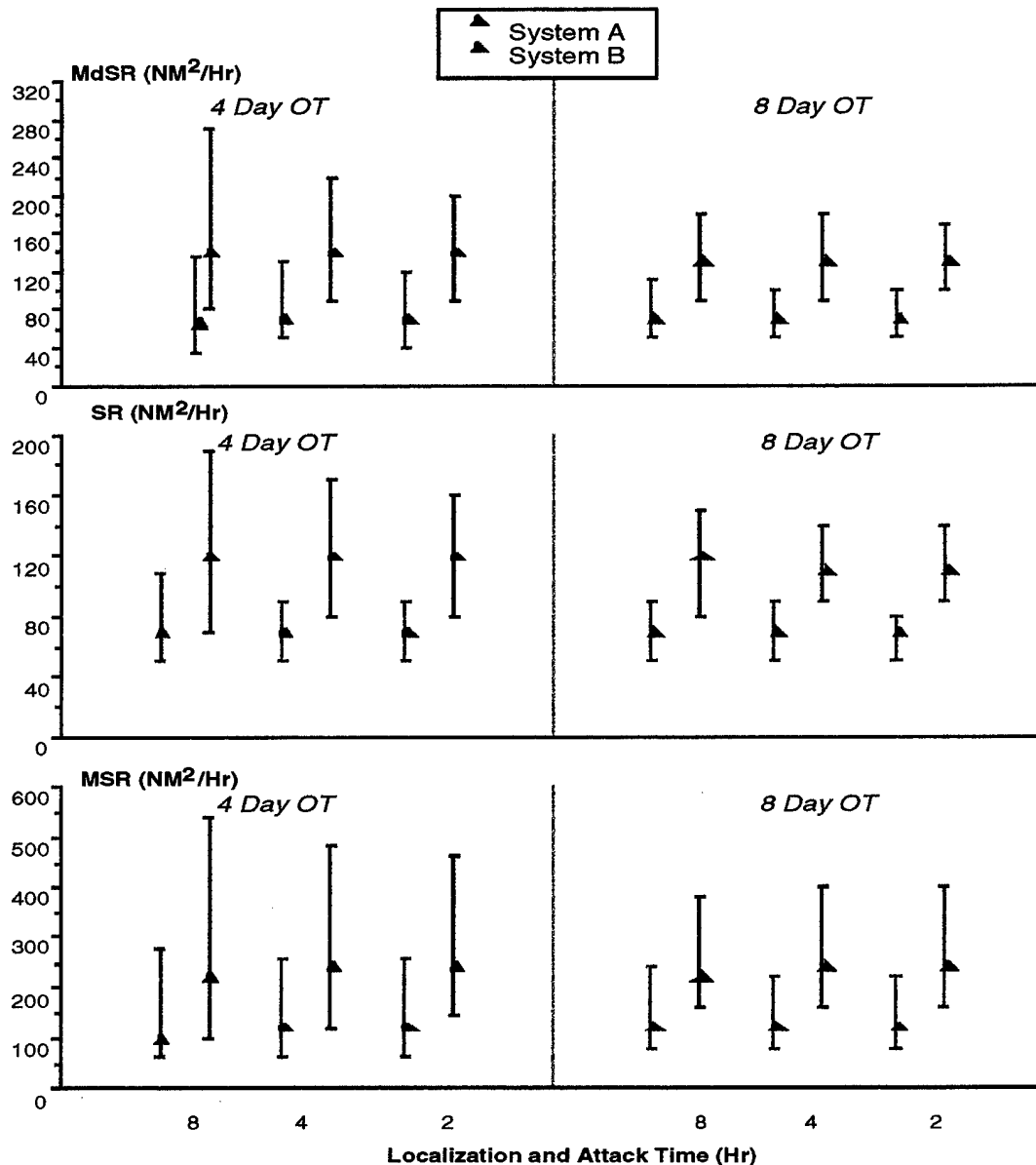


Figure III-16. Effect of Test Conditions on Search MOE Variance (24-Hour Stopping Rule and 25 Percent Shrinkage Rule)

⁹ Figure III-16 compares the results of the following twelve runs: {A|8|2|24|25}, {A|8|4|24|25}, {A|8|8|24|25}, {A|4|2|24|25}, {A|4|4|24|25}, {A|4|8|24|25}, {B|8|2|24|25}, {B|8|4|24|25}, {B|8|8|24|25}, {B|4|2|24|25}, {B|4|4|24|25}, and {B|4|8|24|25}.

We can consider the length of the 80 percent interval, based on 100 trials, for each of our test conditions and test control rules as a measure of variance for our estimates of search-related MOEs. We normalize this 80 percent interval length by dividing it by our “point estimate,” really the median value of the appropriate search-related MOE, to create a parameter that we refer to as the interval length / point estimate (IL/PE). This unitless IL/PE value allows us to gauge the differences in variance between measures and across simulated test situations. One can think of the IL/PE as simply the fraction of the MOE value that the 80 percent interval represents. For example, if the length of the 80 percent interval is two times the magnitude of the median value of the given MOE, the corresponding IL/PE value will be 2.0.

Figure III-17 presents the IL/PE values for a variety of test situations (but always with the 25 percent shrinkage rule). As expected, for all three MOEs, the “variance” (IL/PE) decreases with increasing sample size – resulting from either a longer test duration (8 days versus 4) or less time spent in localization and attack (2, 4, or 8 hours). The IL/PE values are similar for MdSR and SR, with the SR values being somewhat smaller. The IL/PE values associated with MSR are about twice as large as those associated with SR. The suggestion is that the variance associated with estimates of MSR will be significantly greater than those associated with either SR or MdSR.

In addition, Figure III-17 compares IL/PE values for the four different stopping rules that were simulated.¹⁰ First, for System A, there appears to be little consistent impact associated with the choice of test control stopping rule. The exception is the 4-day OT case in which the average localization and attack time is taken as 8 hours, that is, the smallest sample size case for System A. In this exceptional case, the 24-hour stopping rule consistently results in the largest IL/PE for all three MOEs.

For System B, the system that performs at half the level of our expectation, Figure III-17 suggests a greater sensitivity of the IL/PE value to the choice of stopping rule. The suggestion is that the shorter stopping rules, 12 and 16 hours, in general, result in less variance.

¹⁰ Recall, Figure III-16 examined only one stopping rule (24 hours).

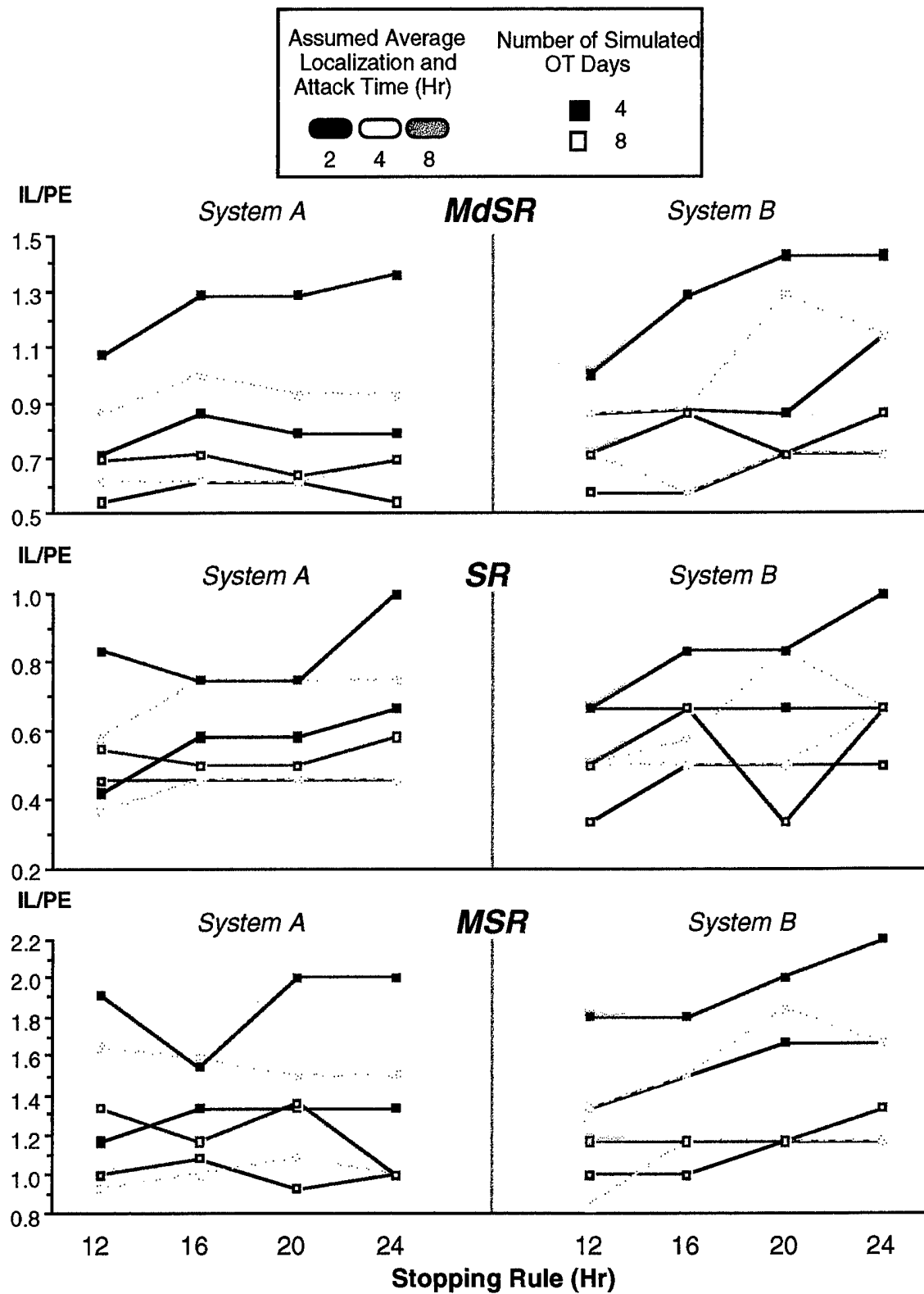


Figure III-17. Effect of Stopping Rule on Search MOE Variance:
25 Percent Shrinkage Rule Only

For completeness, Figure III-18 presents all 288 (96×3) IL/PE values. That is, the solid lines of Figure III-18, correspond exactly to the 48 cases (for each measure) that use the 25 percent shrinkage rule shown in Figure III-17. The various symbols of Figure III-18 correspond to the associated runs with the 50 percent shrinkage rule. The conclusions of the last three paragraphs remain unchanged.

To this point, the MOEs have been computed by simply including the censored data (20 hours, if the trial was stopped at that time) as if they represented detection/classification times. As discussed earlier (page III-5), estimates of MdSR were never affected by this potential bias mechanism. On the other hand, estimates of SR and MSR could be significantly biased given the direct inclusion of this censored data in the calculation of these MOEs. As shown earlier in this chapter (Figures III-4 and III-6), this biasing is expected to be greatest for estimates of SR (vice MSR).

For SR, we can mitigate this effect by estimating the mean time to detect/classify using the MLE technique described in Chapter II (Equation II-10). This technique allows one to incorporate the information available from the truncated trials. Throughout the next section, this technique is used.

With respect to search-related MOEs, our analyses to this point suggest the following:

- Estimates of MSR will have the greatest variance. MdSR and SR will have similar variance associated with their estimation.
- For a system that performs worse than expected (i.e., System B), using shorter stopping rules can decrease the variance of all three MOEs.
- Stopping rules of 16 and 20 hours appear to be a reasonable variance-reducing/realism-maintaining compromise. Avoiding the 12-hour stopping rule and using a 25 percent shrinkage rule, rather than a 50 percent rule, can reduce the likelihood that unrealistically short times to detect/classify are generated for a portion of the test period.
- MdSR can be estimated directly from the observed events. SR can be estimated using an MLE technique that allows for the incorporation of censored data.

All of these interim conclusions are based on systems that perform as described in Chapter II (i.e., Systems A and B).

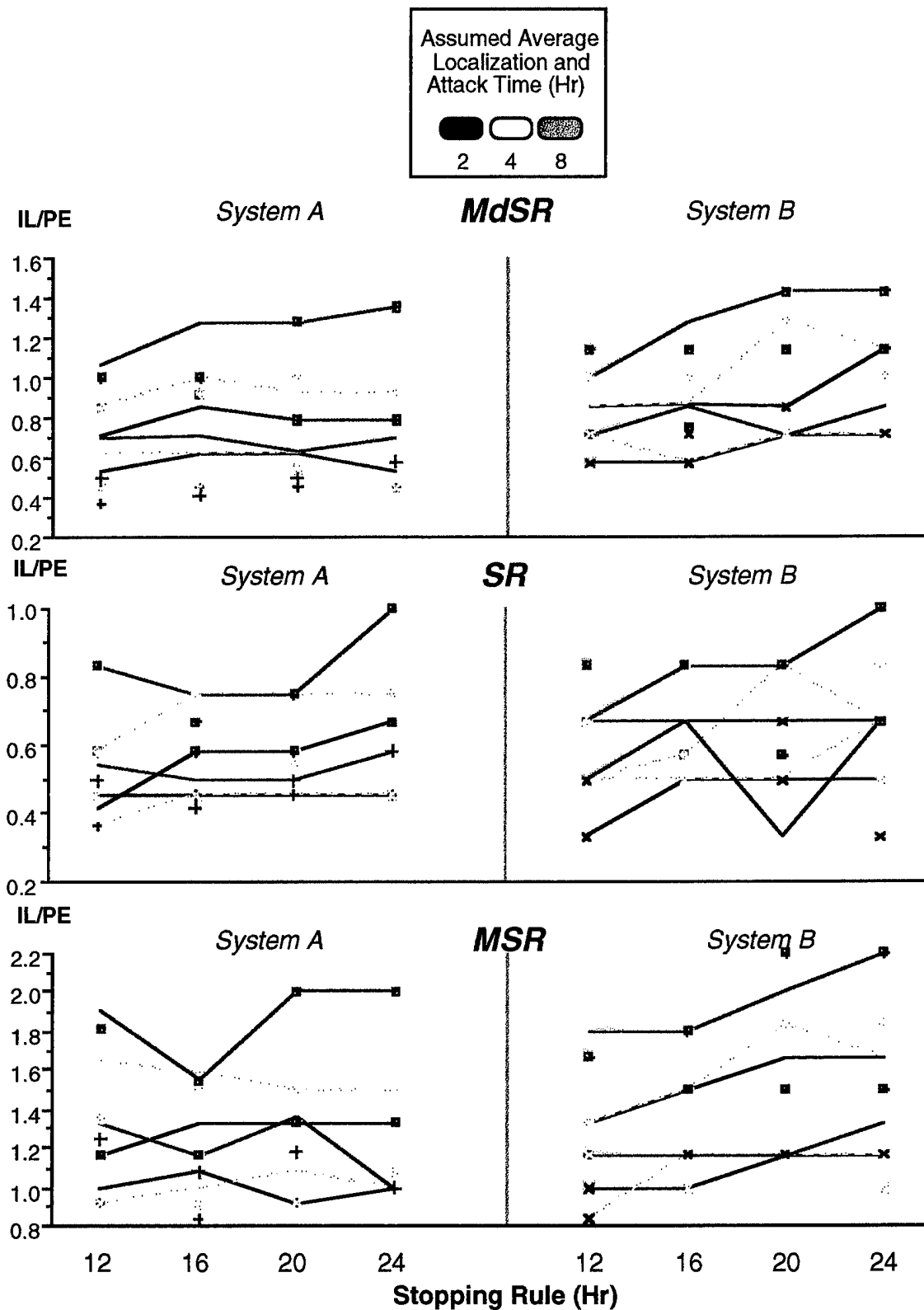


Figure III-18. Effect of Shrinkage Rule on Search MOE Variance

D. A COMPARISON OF SEARCH-RELATED MOEs: HYPOTHESIS TESTING USING PARAMETRIC BOOTSTRAP TECHNIQUES

In this section, we compare our estimates of search-related MOEs obtained from individual simulated OTs (trials) to assumed thresholds. Importantly, this section focuses the examination on the information available from one trial. Of course, this is the type of information that would be available after a real test. That is, at the conclusion of a real OT, only one set of events exists, not 100 as has been the case in our analyses to this point. The thresholds can be thought of as Navy-defined values that are meant to aid the evaluation of system performance based on OT measurements. Our interest in this section is to explore the impact of the choice of test conditions and test control rules on these comparisons to thresholds.

Table III-3 presents estimates of the nominal values for each of the three search-related MOEs for both System A and B. The nominal value of SR was obtained by considering the parameters of the parent gamma distribution (i.e., $SR = \text{area size} / \text{mean time to detect/classify} = \text{Area size} / (\alpha \times \beta)$). For MdSR and MSR, 26,000 random numbers were drawn from the appropriate gamma distribution and the individual search rates (sr_i s) were computed. MdSR and MSR were then computed, as described in Chapter II, from these 26,000 values.

Table III-3. Nominal Values of MdSR, SR, and MSR (NM²/Hr)

MOE	System A	System B
MdSR	132	67
SR	106	53
MSR	260	133

For illustrative purposes, we consider thresholds for MdSR and SR between 40 and 160 NM²/Hr. For MSR, we double these values, and consider thresholds between 80 and 320 NM²/Hr. Table III-4 lists these thresholds and notes whether the system under test, A or B, is expected to “pass” or “fail” the given threshold. In a sense, the “correct” answers are given in Table III-4. The rest of this section examines how well a given test situation (test conditions and control rules) allows one to discern these correct answers.

Table III-4. Pass/Fail Expectations for Three Search-Related MOEs

Thresholds (NM ² /Hr)		System A			System B		
<i>MdSR, SR</i>	<i>MSR</i>	<i>MdSR</i>	<i>SR</i>	<i>MSR</i>	<i>MdSR</i>	<i>SR</i>	<i>MSR</i>
40	80	Pass	Pass	Pass	Pass	Pass	Pass
50	100	Pass	Pass	Pass	Pass	Pass	Pass
60	120	Pass	Pass	Pass	Pass	Fail	Pass
70	140	Pass	Pass	Pass	Fail	Fail	Fail
80	160	Pass	Pass	Pass	Fail	Fail	Fail
90	180	Pass	Pass	Pass	Fail	Fail	Fail
100	200	Pass	Pass	Pass	Fail	Fail	Fail
110	220	Pass	Fail	Pass	Fail	Fail	Fail
120	240	Pass	Fail	Pass	Fail	Fail	Fail
130	260	Pass	Fail	Pass	Fail	Fail	Fail
140	280	Fail	Fail	Fail	Fail	Fail	Fail
150	300	Fail	Fail	Fail	Fail	Fail	Fail
160	320	Fail	Fail	Fail	Fail	Fail	Fail

Using the parametric bootstrap procedures that were outlined in Chapter II, we can, for an individual trial, compute the percent confidence that the system under test has an actual search-related MOE value greater than or equal to the given threshold value. Recall that this procedure involves first estimating the shape and scale parameters of the assumed underlying gamma distribution from the observed times to detect/classify and truncations using the MLE technique described in Chapter II. Next, resampling of this fitted gamma distribution is done ($2,000 \times$ number of total events) to generate bootstrap samples of the appropriate search-related MOE. From these 2,000 bootstrap samples, confidence intervals, for example, can be estimated.

Table III-5, in a format similar to Table III-4, presents the results of these parametric bootstrap calculations for one particular trial of one test situation. The bold

Table III-5. Percent Confidence That One Can Ascribe to the Claim That the System Attains the Given Threshold: Trial 1 of Run {A|8|4|20|25} and Trial 1 of Run {B|8|4|20|25}

Thresholds (NM ² /Hr)		System A			System B		
<i>MdSR, SR</i>	<i>MSR</i>	<i>MdSR</i>	<i>SR</i>	<i>MSR</i>	<i>MdSR</i>	<i>SR</i>	<i>MSR</i>
40	80	100	100	100	99	95	98
50	100	100	100	100	92	73	93
60	120	100	100	100	77	42	84
70	140	100	99	98	58	20	73
80	160	98	93	96	43	9	62
90	180	94	82	91	31	3	53
100	200	87	65	85	21	1	45
110	220	79	48	79	13	1	38
120	240	70	34	72	9	0	33
130	260	61	23	65	6	0	28
140	280	50	15	57	4	0	25
150	300	40	10	51	3	0	22
160	320	34	6	46	2	0	20

underlines drawn into Table III-5 indicate the location of our pass/fail expectation of system performance (as in Table III-4). Figure III-19 presents the data of Table III-5 graphically. Figure III-19 allows one to compare, for this one trial, the “confidence curves” for the three MOEs and two systems. The ideal test would result in a 0-100 step-function occurring at the MOE’s nominal value (e.g., 106 NM²/Hr for System A’s SR). The sharper the slope of the s-shaped curves shown in Figure III-19, the better the chance of discerning specific system performance versus a given threshold. Given this relationship, it is clear from Figure III-19 that MSR represents the MOE that would be most difficult to discern from a given threshold (for this trial). Alternatively, SR appears to be the MOE that most likely would lead to a statistically based conclusion when its point estimate is compared to a given threshold.

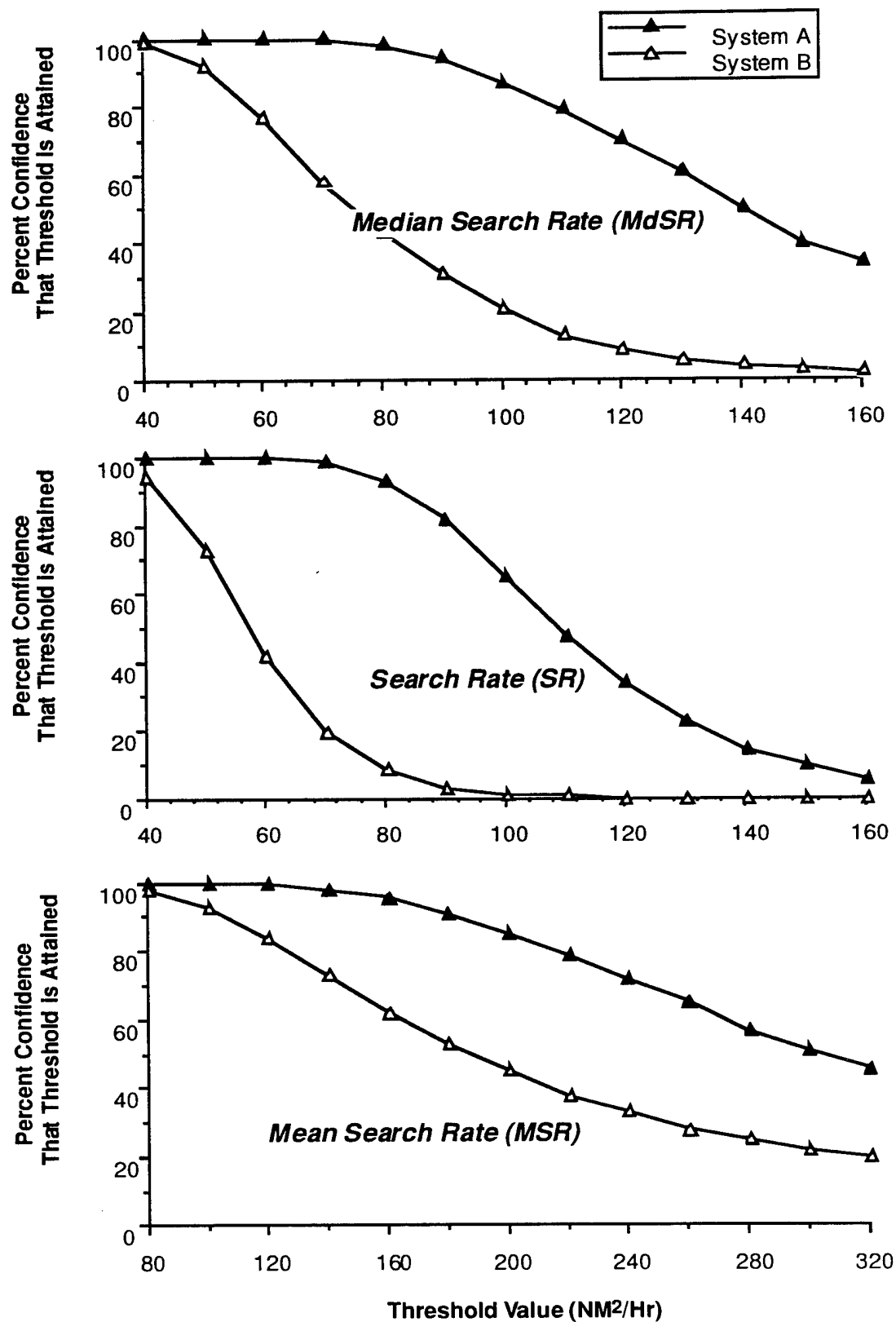


Figure III-19. Percent Confidence That One Can Ascribe to the Claim That the System Attains the Given Threshold: Trial 1 of Runs {A|8|4|20|25} and {B|8|4|20|25}

Given the way in which we currently are doing these calculations, on a personal computer spreadsheet, it would be impractical for the parametric bootstrap examinations described above to be done for all 9,600 trials that were simulated. (The implication is that $9,600 \times 2,000$, or about 19.2 million bootstrap samples would be required, with each bootstrap sample requiring between 4 and 21 random draws from the differing fitted gamma distributions, plus all the appropriate calculations of MOEs.) Rather than a complete parametric bootstrap examination, we focus on a few illustrative trials. Our goal is to describe the potential impact of differing test control rules and to describe the potential value and limitations of the various search-related MOEs.

Table III-6 shows the total number of events and events taken to completion for the first 10 trials of a comparable System A and System B run – with both runs involving an 8-day test, an assumed average time for localization and attack of 4 hours, a stopping rule of 20 hours, and a shrinkage percentage of 25. The MLE-fitted gamma parameters, α' and β' , are also shown in Table III-6. The shape and scale parameters for the fitted gamma distribution can differ quite substantially for these relatively small sample size MLE-fits.

Table III-6. First 10 Trials of Runs {A|8|4|20|25} and {B|8|4|20|25} ^a

Trial #	System A				System B			
	Tev	EvTC	α'	β'	Tev	EvTC	α'	β'
1	15	14	1.38	5.36	12	9	1.22	11.55
2	15	15	1.65	3.64	11	9	2.54	4.92
3	16	16	1.51	3.90	12	10	1.15	10.19
4	16	16	1.22	4.62	12	11	1.96	5.22
5	16	16	2.13	2.78	13	11	1.00	13.20
6	15	15	2.83	2.16	12	10	2.83	3.99
7	15	15	2.00	3.02	11	10	5.84	1.97
8	13	12	1.14	7.32	12	10	2.30	5.30
9	14	12	1.00	9.83	12	10	2.00	6.29
10	15	14	1.00	6.69	12	9	1.08	15.14

^a Tev = total number of events, EvTC = events taken to completion, α' = estimated gamma shape parameter, β' = estimated gamma scale parameter. SR is given in NM²/Hr.

Figure III-20 presents the confidence curves for these 10 trials as was done for trial 1 in Figure III-19. Figure III-20 shows how these confidence curves, which one could build after a particular test, can vary – at least for our gamma distributed times to detect/classify and given the application of our test control rules. Again, it is clear that hypothesis testing of MSR, versus some threshold, would be least likely to lead to a definitive, statistically based conclusion.

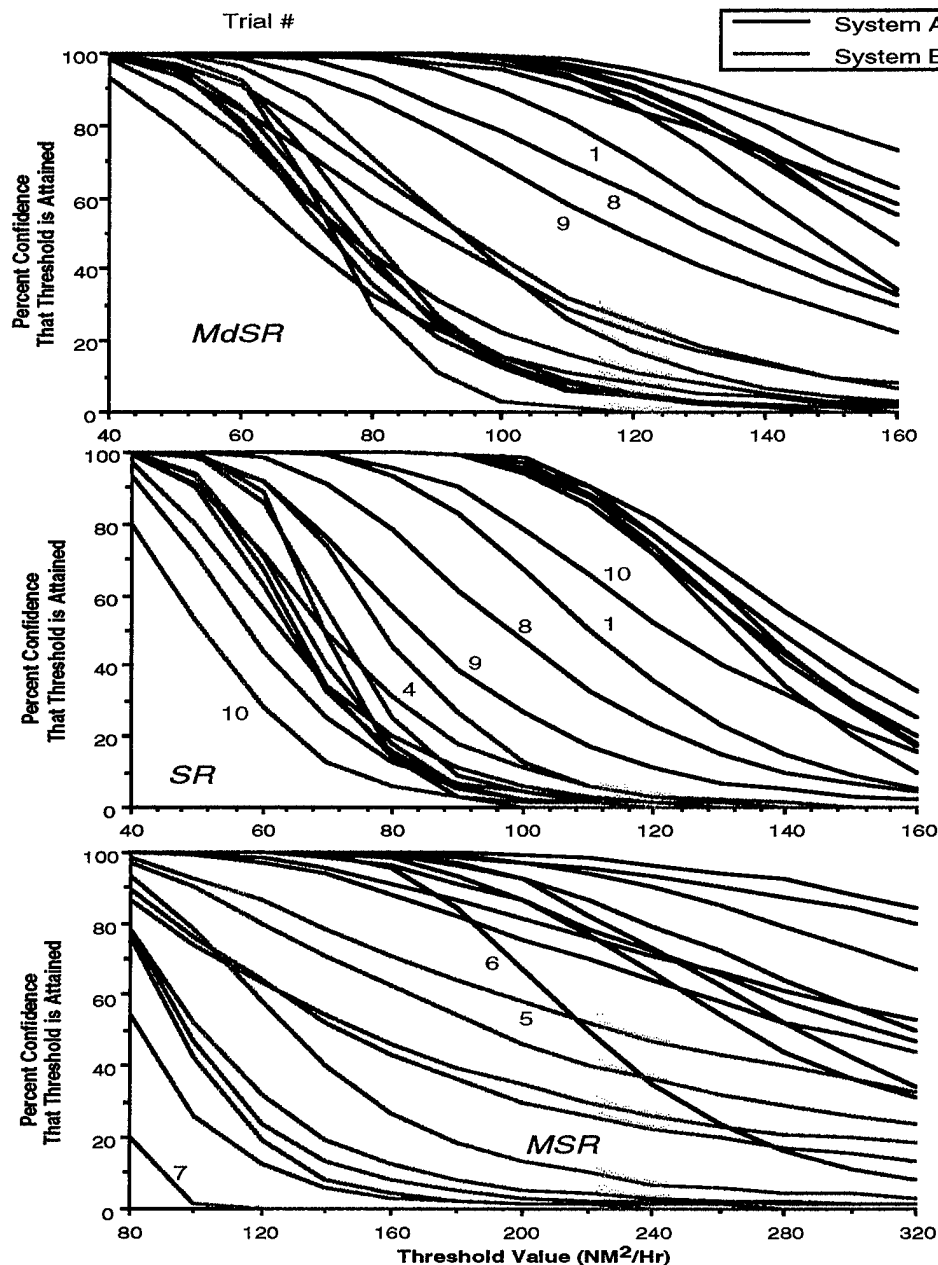


Figure III-20. Percent Confidence That One Can Ascribe to the Claim That the System Attains the Given Threshold: Trials 1 Through 10 of Runs {A1814120125} and {B1814120125}

Next, we consider the length of the 80 percent interval associated with the 2,000 bootstrap MOE samples. We normalize this interval to the expected MOE value (Table III-3) and create the unitless IL/PE value, this time from the bootstrap sample. We also consider the percentage of bootstrap samples (out of a total of 2,000) that are greater than or equal to the expected MOE value. We refer to this as the approximate percent confidence (PercConf) that one can ascribe to the claim that the system attains the given threshold. Ideally, one would like the chosen MOE to have an IL/PE value near zero for all trials and a PercConf value clustered around one point for all trials.

For each of the 20 trials described in Table III-6, we present a scatterplot of PercConf versus IL/PE (Figure III-21). Each of the points in Figure III-21 represents a different trial (1 through 10) or a different MOE (MdSR, SR, or MSR). This scatterplot is meant to show the interaction between IL/PE and PercConf. The between-trials variance associated with the sorts of conclusions that one might come to if MSR was used as the search-related MOE is apparent from Figure III-21. In particular, for the trials in which the IL/PE value is relatively low for MSR (below 1.0), the PercConf value is also low (below 60 percent). Alternatively, for those trials that led to higher PercConf values for MSR, the IL/PE values are large.

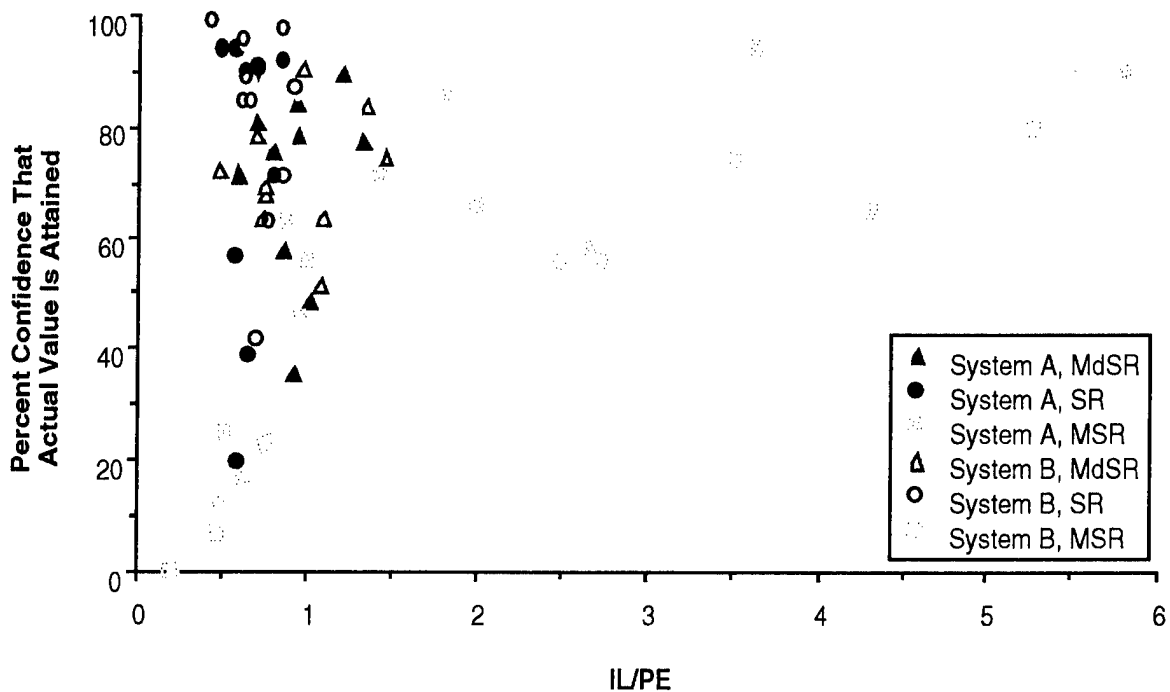


Figure III-21. Scatterplot of Percent Confidence That Actual MOE Value Is Attained Versus IL/PE for the First 10 Trials of Runs {A1814120125} and {B1814120125}

SR and MdSR appear to have similar behavior for these 10 trials, with MdSR being slightly more dispersed in IL/PE and SR being slightly more dispersed in PercConf. Given the above-described ideal requirements, SR and MdSR appear to be of similar merit with respect to their usage as measures to be compared to predefined thresholds.

Table III-7 considers the first trial of 32 different runs. This table reports the MLE-fitted gamma parameters and estimated SR for the first trial of each of these 32 different test situations.

Table III-7. First Trial of 32 Different Runs^a

Case #	Run Description	System A					System B				
		Tev	EvTC	α'	β'	SR	Tev	EvTC	α'	β'	SR
1	{8 4 24 50}	14	14	1.40	5.19	110	12	10	1.26	10.91	58
2	{8 4 24 25}	14	14	1.40	5.19	110	12	10	1.26	10.91	58
3	{8 4 20 50}	15	14	1.38	5.36	108	13	11	1.39	9.66	60
4	{8 4 20 25}	15	14	1.38	5.36	108	12	9	1.22	11.55	60
5	{8 4 16 50}	15	14	1.48	4.81	112	17	14	1.00	14.51	55
6	{8 4 16 25}	15	14	1.48	4.81	112	13	10	1.37	9.98	59
7	{8 4 12 50}	18	16	1.66	4.14	116	19	16	1.77	7.49	60
8	{8 4 12 25}	17	15	1.58	4.49	113	16	12	1.55	9.27	56
9	{4 4 24 50}	7	7	1.22	4.06	162	4	4	6.97	2.08	55
10	{4 4 24 25}	7	7	1.22	4.06	162	4	4	6.97	2.08	55
11	{4 4 20 50}	7	7	1.22	4.06	162	5	4	5.41	2.60	57
12	{4 4 20 25}	7	7	1.22	4.06	162	5	4	5.41	2.60	57
13	{4 4 16 50}	8	7	1.00	7.23	111	7	5	1.00	12.68	63
14	{4 4 16 25}	8	7	1.00	7.23	111	7	5	1.00	12.68	63
15	{4 4 12 50}	8	7	1.06	6.23	121	8	5	1.04	12.82	60
16	{4 4 12 25}	8	7	1.06	6.23	121	8	5	1.04	12.82	60

^a Tev = total number of events, EvTC = events taken to completion, α' = estimated gamma shape parameter, β' = estimated gamma scale parameter.

It was often true that small changes in test control rules, for instance cases 1 and 2, led to no changes in the simulated outcome of the OT.¹¹ Therefore, the number of trials, number of truncations, and observed times to detect/classify for these cases with similar test control rules would be identical. This phenomena can be recognized in Table III-7 as the identical pairs of estimated gamma parameters (e.g., cases 1 and 2 or 15 and 16).

For the 8-day tests of System A, shown in Table III-7, estimates of SR vary from 108 to 116 NM²/Hr. Four-day estimates of SR vary much more – from 111 to 162 NM²/Hr. For System B, these particular trials showed little variation in estimates of SR. See Table III-7.

From the runs of Table III-7, plots of PercConf and IL/PE versus run conditions are shown for Systems A and B in Figure III-22. Given the previously described deficiency with MSR as an MOE, namely, relatively large variance associated with estimates of MSR, it has not been included in Figure III-22. In addition, only the non-redundant cases are plotted in Figure III-22. For example, System A case 1 is presented, but not System A case 2.

With respect to System A, the impact of test duration is most apparent. In particular, the IL/PE value, our measure of variance, increases dramatically for the shorter test (case numbers 9, 11, 13, and 15 for System A). For this trial, it is also seen that dropping the stopping rule from 24 to 12 hours and using a 50 percent vice 25 percent shrinkage rule (case 7), led to the smallest values of IL/PE and did not appreciably affect the PercConf estimates. We note that, for System B, the PercConf value associated with the case 7 SR rises above all others (for System B). This may be a manifestation of the upward biasing of SR when the 12-hour stopping rule and 50 percent shrinkage rule are employed together, as discussed earlier.¹² The final feature associated with this Figure is the unexpectedly low PercConf associated with MdSR for System B cases 9 and 11. As can be seen in Table III-7, the MLE-fits for these very small sample size cases (four events) can vary substantially and hence lead to very different conclusions, given that the aforementioned parametric bootstrap methodology is employed for threshold comparisons. For these data, the SR MOE appears to be somewhat more robust to this variance mechanism. That is, although the fitted shape and scale parameters are quite different for the eight, 4-day, System B tests, the computed

¹¹ Recall that the same set of random numbers was used for each test situation.

¹² The same biasing effect on SR can be seen in case 7 for System A (Figure III-23).

PercConf values vary by less than 20 percent (from 60 to 72) for SR. The comparable MdSR values vary by 217 percent (from 23 to 73).

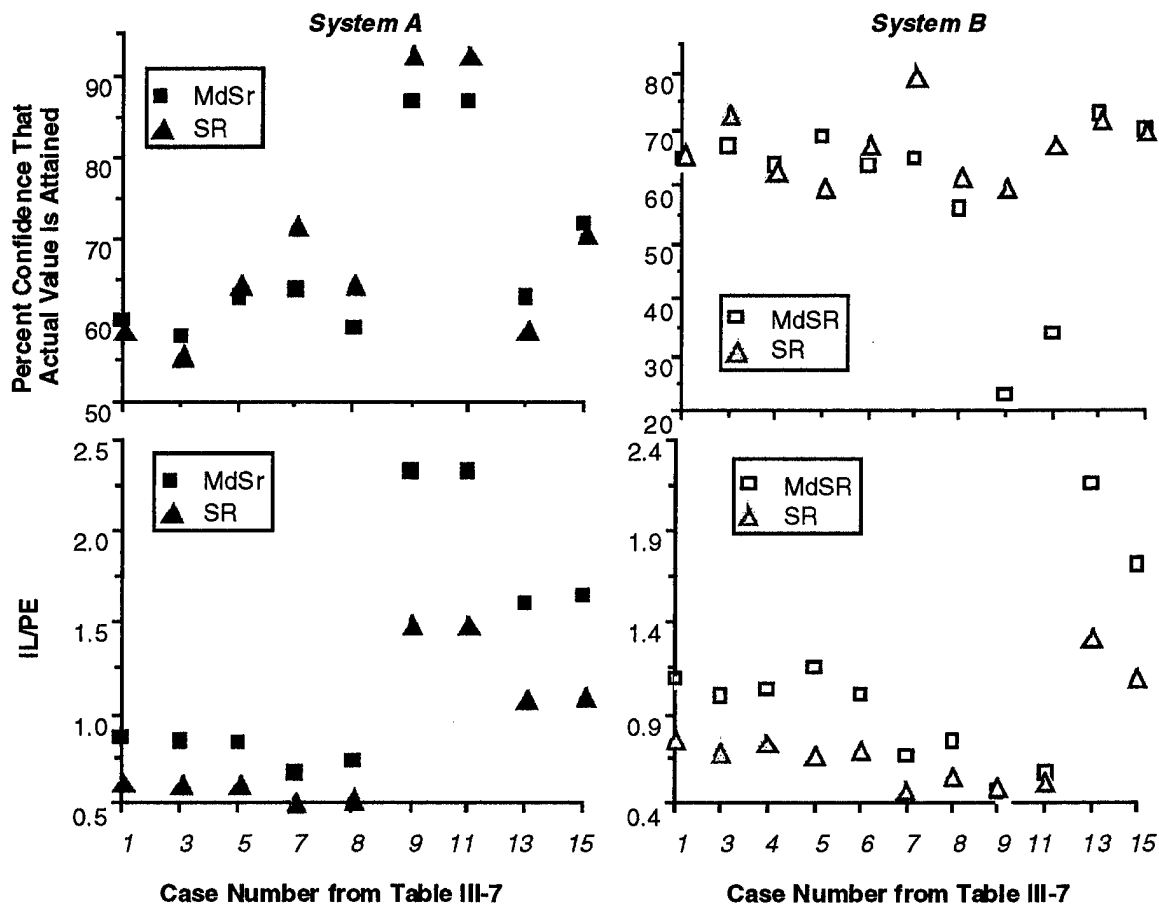


Figure III-22. Impact of Test Control Rules on Percent Confidence That MOE Value Is Attained and IL/PE for MdSR and SR

E. CONCLUSIONS

With respect to the employment of test control rules, the analyses of this chapter support the following conclusions:

1. Employing stopping rules for free-play ASW search OT can increase the number of encounters generated during the test and maintain elements of test realism. The use of such rules will be particularly valuable when the system under test performs significantly worse than pre-test expectations.
2. Longer test periods (on the order of 8 days or more rather than 4 days) are more likely to be positively affected by the test control rules described in this

document. That is, free-play test durations of 4 days or fewer will be only minimally affected by the rules described in this document.

3. The use of the 12-hour stopping rule with a 50 percent shrinkage rule led to unrealistically short times to detect/classify for some trials. For the system performances examined (i.e., System A and B), stopping rules of 16, 20, and 24 hours, used in concert with 50 or 25 percent shrinkage rules, appeared satisfactory from this perspective.
4. With respect to the search-related MOEs that were investigated:
 - In the case of SR and MdSR, stopping rules of 16 and 20 hours appeared to represent a reasonable variance-reducing/realism-maintaining compromise.
 - The MSR, because of the large variance associated with its estimation, does not appear to be a good choice for a search-related MOE.
 - Given the employment of the test control rules described in this document, both MdSR and SR appear to represent satisfactory search-related MOEs. Whereas MdSR can be directly estimated from the observed events, an MLE procedure should be used to include censored data in estimates of SR.
 - Given a “set of observations” (trial), a parametric bootstrap technique can be used to estimate the given search-related MOE and to attach confidence intervals. In addition, in the case of MdSR and SR, this technique can be used to arrive at statistically based conclusions (e.g., hypothesis testing) relative to predefined thresholds.

REFERENCES

- III-1. *Operational Test and Evaluation (OT&E) Concepts for Attack Submarines*, IDA Paper P-2843, 8 November 1993.

APPENDIX A

ACRONYMS

APPENDIX A

ACRONYMS

ASW	Anti-Submarine Warfare
Avg	Average
BARSTUR	Barking Sands Tactical Underwater Range
BSURE	Barking Sands Underwater Range Expansion
C.I.	Confidence Interval
COI	Critical Operational Issue
COMEX	Commencement of the Exercise
COMOPTEVFOR	Commander, Operational Test and Evaluation Force
DOT&E	Director Operational Test and Evaluation
EvTC	Events Taken to Completion
FASz	Final Area Size
FINEX	Finish Exercise
FOM	Figure-of-Merit
Hr	Hour
IDA	Institute for Defense Analyses
IL/PE	Interval Length / Point Estimate
L&A	Localization and Attack
Loc	Localization
MDR	Median Detection Range
MdSR	Median Search Rate
MLE	Maximum Likelihood Estimation
MOE	Measure of Effectiveness
MOP	Measure of Performance
MSR	Mean Search Rate
NM ²	Square Nautical Miles
NT	Normalized Time
NT(C)	Normalized Time With Censored Data
OPEVAL	Operational Evaluation
OPTEVFOR	Operational Test and Evaluation Force
OT	Operational test
OTD	Operational Test Director

OT&E	Operational Test and Evaluation
PercConf	Percent Confidence
Repo	Reposition
RndT	Random Time
RndT(C)	Random Time With Censored Data
SR	Search Rate
Tev	Total Events

APPENDIX B

SIMULATION RESULTS

APPENDIX B

SIMULATION RESULTS

This appendix presents the results, in a table, of the 96 test situations that were simulated in this study. Each situation or run is characterized by a different set of initial test conduct/test control conditions. Definitions for each of these test conduct/test control initial conditions are given in Table B-1. Similarly, Table B-2 identifies and defines the various output measures (results) that are presented. Finally, Table B-3 presents the information described in Tables B-1 and B-2 for each of the 96 runs. For each run (i.e., test situation) and each output measure, listings describing the frequency of occurrence for various values are provided. These listings are suitable for defining histograms for each measure and as such, provide an estimate of how each measure is distributed.

Table B-1. Test Situation Input Parameters

Parameter	Description
SYSTEM	"A" corresponds to a nominal system with an average time to detect/classify of 7.54 hours and "B" corresponds to a system with an average time to detect/classify of 15.08 hours
Start Area	This value represents the area size at the start of the test. This value was chosen as 800 NM ² for all runs.
Days	This number corresponds to the length of the simulated OT (or trial) (4 or 8 days).
Loc Time	This number corresponds to the time added to each detection/classification for localization and attack (2, 4, or 8).
Repo Time	This number (in hours) corresponds to the time added to each detection/classification or truncation for repositioning after the encounter or truncation.
Stop Time	This is the time (in hours) at which the OTD, given no detection/classification, stops the event (12, 16, 20, and 24).
Shrink %	This is the percentage (25 or 50) that the OTD shrinks the area size to be searched given he has observed two or more truncations during that simulated OT (trial).
6-Pt Time	If the running six-point average during a given simulated OT (trial) goes below this value, the OTD expands the area size for the next search. This value was always chosen as 1.5 hours for the 96 runs reported here.
5-Pt Time	If the running five-point average during a given simulated OT (trial) goes below this value, the OTD expands the area size for the next search. This value was always chosen as 1.0 hours for the 96 runs reported here.
Expand %	This is the percentage that the OTD expands the area size to be searched given the six-point or five-point expansion rules have been triggered. This number was chosen as 200 for all of the reported runs. (See footnote 19 of Chapter II, page II-17.)

Table B-2. Description of Output Measures

Measure	Description
EvTC	The number of events per trial that were completed with a simulated encounter.
Tev	The total number of events per trial. That is, events that ended with a simulated encounter or OTD-forced truncation are included.
FASz	The number of trials in which the area size being searched (in NM ²) on the final event was of a specified value.
RndT	The number of trials in which the average time to detection/classification (of the random draw – in hours) was of a specified value.
RndT(C)	The number of trials in which the average time to detection/classification (of the random draw with the censoring (truncations) due to the test control rules – in hours) was of a specified value. That is, this value corresponds to a censored average.
MdSR	The frequency of the computed median search rates (in NM ² /Hr).
A/Avg(NT)	The frequency of the computed search rates (SR) (in NM ² /Hr and normalized to 800 NM ²) based solely on the random draws. (See page II-16, Equation II-5a for definition of SR.)
A/Avg(NT(C))	The frequency of the computed search rates (SR) (in NM ² /Hr) based on the random draws with censoring due to the test control rules.
MSR	The frequency of the computed mean search rates (in NM ² /Hr) based solely on the random draws.
MSR(C)	The frequency of the computed mean search rates (in NM ² /Hr) based on the random draws with censoring due to the test control rules.

Table B-3. Simulation Results

Run #	SYSTEM	Start Area	Days	Loc Time	Rep Time	Stop Rules	Shrink %	Expand Rules	6-PI Time	5-PI Time	Expand %	EVT	Tev	FASz	RndT	RndT(C)	MSR	A/Vg(NT)	A/Vg(NTC)	MSR	MSR(C)
												Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin
1	A	800	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	2	3	0	2	0	95	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
24	5	6	5	3	169	0	5	5	5	5	5	0	0	0	0	0	0	0	0	0	0
50%	6	9	6	12	200	0	6	20	6	1	60	0	0	0	0	0	0	0	0	0	0
1.5	7	20	7	16	225	0	7	25	7	3	70	0	0	0	0	0	0	0	0	0	0
1	8	20	8	24	254	0	8	18	8	5	80	0	0	0	0	0	0	0	0	0	0
200%	9	28	9	29	300	0	9	13	9	11	90	0	0	0	0	0	0	0	0	0	0
	10	14	10	14	338	0	10	7	10	6	100	0	0	0	0	0	0	0	0	0	0
	11	11	11	11	400	0	11	3	11	4	110	0	0	0	0	0	0	0	0	0	0
	12	1	12	1	450	0	12	8	12	7	120	0	0	0	0	0	0	0	0	0	0
	13	0	13	0	600	0	13	2	13	2	130	0	0	0	0	0	0	0	0	0	0
	14	0	14	0	800	100	14	0	14	0	140	0	0	0	0	0	0	0	0	0	0
	15	0	15	0	900	0	15	0	15	0	150	0	0	0	0	0	0	0	0	0	0
	16	0	16	0	1200	0	16	0	16	0	160	0	0	0	0	0	0	0	0	0	0
	17	0	17	0	1600	0	17	0	17	0	170	0	0	0	0	0	0	0	0	0	0
	18	0	18	0	More	U	18	0	18	0	180	0	0	0	0	0	0	0	0	0	0
	19	0	19	0	More	U	19	0	19	0	190	0	0	0	0	0	0	0	0	0	0
	20	0	20	0	More	U	20	0	20	0	200	0	0	0	0	0	0	0	0	0	0
	21	0	21	0	More	U	21	0	21	0	210	0	0	0	0	0	0	0	0	0	0
	22	0	22	0	More	U	22	0	22	0	220	0	0	0	0	0	0	0	0	0	0
	23	0	23	0	More	U	23	0	23	0	230	0	0	0	0	0	0	0	0	0	0
	24	0	24	0	More	U	24	0	24	0	240	0	0	0	0	0	0	0	0	0	0
	25	0	25	0	More	U	25	0	25	0	250	0	0	0	0	0	0	0	0	0	0
	26	0	26	0	More	U	26	0	26	0	260	0	0	0	0	0	0	0	0	0	0
	27	0	27	0	More	U	27	0	27	0	270	0	0	0	0	0	0	0	0	0	0
	28	0	28	0	More	U	28	0	28	0	280	0	0	0	0	0	0	0	0	0	0
	29	0	29	0	More	U	29	0	29	0	290	0	0	0	0	0	0	0	0	0	0
	30	0	30	0	More	U	30	0	30	0	300	0	0	0	0	0	0	0	0	0	0
	More	U	More	U	More	U	More	U	More	U	More	U	More	U	More	U	More	U	More	U	More

Table B-3. Simulation Results (cont)

Run #	SYSTEM	Start Area	Days	Loc Time	Repo Time	Stop Rules	Shrink %	Expand Rules	6-PT Time	5-PT Time	Expand %
3	A	800	4	2	2	20	50%	1.5	1	200%	
EVTC	#	Tev	FASz	RndT	RndTC	MSR	A/Avg(MT)	A/Avg(TC)	MSR	MSR(C)	#
Bin		Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin	#
0	0	0	0	0	0	0	0	0	0	0	0
1	0	1	0	0	0	0	0	0	0	0	0
2	0	2	0	0	0	0	0	0	0	0	0
3	0	3	0	0	0	0	0	0	0	0	0
4	1	4	0	0	0	0	0	0	0	0	0
5	8	5	2	169	0	5	7	50	0	100	5
6	7	6	6	200	0	6	17	60	1	120	5
7	21	7	20	225	0	7	28	70	3	140	3
8	19	8	22	254	0	8	21	80	6	160	5
9	29	9	33	300	0	9	90	90	6	180	11
10	12	10	11	338	0	10	110	100	9	200	9
11	3	11	4	400	0	11	6	110	16	220	9
12	0	12	0	450	0	12	12	120	13	240	12
13	0	13	0	450	0	13	11	130	15	260	9
14	0	14	0	600	0	14	140	140	13	280	7
15	0	15	0	600	0	15	150	150	5	300	3
16	0	16	0	1200	0	16	160	160	5	320	3
17	0	17	0	1600	0	17	170	170	4	340	2
18	0	18	0	1600	0	18	180	180	2	360	2
19	0	19	0	19	0	19	190	190	2	380	2
20	0	20	0	20	0	20	200	200	1	400	0
21	0	21	0	21	0	21	210	210	1	420	1
22	0	22	0	22	0	22	220	220	0	440	2
23	0	23	0	23	0	23	230	230	0	460	0
24	0	24	0	24	0	24	240	240	0	480	0
25	0	25	0	25	0	25	250	250	0	500	3
26	0	26	0	26	0	26	260	260	0	520	0
27	0	27	0	27	0	27	270	270	0	540	1
28	0	28	0	28	0	28	280	280	0	560	1
29	0	29	0	29	0	29	290	290	0	580	0
30	0	30	0	30	0	30	300	300	0	600	0
More	U	More	U	More	U	More	350	350	0	More	2

Run #	SYSTEM	Start Area	Days	Loc Time	Repo Time	Stop Rules	Shrink %	Expand Rules	6-PT Time	5-PT Time	Expand %
4	A	800	4	2	2	20	25%	1.5	1	200%	
EVTC	#	Tev	FASz	RndT	RndTC	MSR	A/Avg(MT)	A/Avg(TC)	MSR	MSR(C)	#
Bin		Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin	#
0	0	0	0	0	0	0	0	0	0	0	0
1	0	1	0	0	0	0	0	0	0	0	0
2	0	2	0	0	0	0	0	0	0	0	0
3	0	3	0	0	0	0	0	0	0	0	0
4	1	4	0	0	0	0	0	0	0	0	0
5	8	5	2	169	0	5	7	50	0	100	5
6	7	6	6	200	0	6	17	60	1	120	5
7	21	7	20	225	0	7	28	70	3	140	3
8	19	8	22	254	0	8	21	80	6	160	5
9	29	9	33	300	0	9	90	90	6	180	11
10	12	10	11	338	0	10	110	100	9	200	9
11	3	11	4	400	0	11	6	110	16	220	9
12	0	12	0	450	0	12	12	120	13	240	12
13	0	13	0	450	0	13	11	130	15	260	9
14	0	14	0	600	0	14	140	140	13	280	7
15	0	15	0	600	0	15	150	150	5	300	3
16	0	16	0	1200	0	16	160	160	5	320	3
17	0	17	0	1600	0	17	170	170	4	340	2
18	0	18	0	1600	0	18	180	180	2	360	2
19	0	19	0	19	0	19	190	190	2	380	2
20	0	20	0	20	0	20	200	200	1	400	0
21	0	21	0	21	0	21	210	210	1	420	1
22	0	22	0	22	0	22	220	220	0	440	2
23	0	23	0	23	0	23	230	230	0	460	0
24	0	24	0	24	0	24	240	240	0	480	0
25	0	25	0	25	0	25	250	250	0	500	3
26	0	26	0	26	0	26	260	260	0	520	0
27	0	27	0	27	0	27	270	270	0	540	1
28	0	28	0	28	0	28	280	280	0	560	1
29	0	29	0	29	0	29	290	290	0	580	0
30	0	30	0	30	0	30	300	300	0	600	0
More	U	More	U	More	U	More	350	350	0	More	2

Table B-3. Simulation Results (cont)

Run #	SYSTEM	Start Area	Days	Loc Time	Rejo Time	Stop Rules	Shrink %	Expand Rules	6-PT Time	5-PT Time	Expand %	EvTC		Tev		FASz		RndT		RndT(C)		MSR		A/Avg(NT)		A/Avg(NT(C))		MSR		MSR(C)	
												#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin
5	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
A	4	1	0	1	0	50	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2	2	0	0	2	0	95	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2	2	3	0	3	0	100	0	3	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
16	5	4	2	4	0	127	0	4	1	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
50%	6	10	6	5	0	169	0	5	7	5	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1.5	7	24	7	17	225	0	6	16	6	20	60	1	60	2	100	2	100	2	100	2	100	2	100	2	100	2	100	2	100	2	100
1	8	25	8	31	254	0	7	20	7	28	70	1	70	2	140	7	140	7	140	7	140	7	140	7	140	7	140	7	140	7	140
200%	9	20	9	30	300	0	9	11	9	12	90	9	90	6	180	10	180	10	180	10	180	10	180	10	180	10	180	10	180	10	180
	10	12	10	17	338	0	10	8	10	5	100	10	100	9	180	9	180	9	180	9	180	9	180	9	180	9	180	9	180	9	180
	11	2	11	2	400	11	11	4	11	4	110	11	110	13	260	13	260	13	260	13	260	13	260	13	260	13	260	13	260	13	260
	12	0	12	1	450	0	12	2	12	0	120	12	120	13	260	13	260	13	260	13	260	13	260	13	260	13	260	13	260	13	260
	13	0	13	0	600	0	13	1	13	1	130	13	130	13	260	13	260	13	260	13	260	13	260	13	260	13	260	13	260	13	260
	14	0	14	0	800	89	14	1	14	1	140	14	140	8	160	8	160	8	160	8	160	8	160	8	160	8	160	8	160	8	160
	15	0	15	0	900	0	15	0	15	0	150	15	150	6	150	6	150	6	150	6	150	6	150	6	150	6	150	6	150	6	150
	16	0	16	0	1200	0	16	1	16	1	160	16	160	9	160	9	160	9	160	9	160	9	160	9	160	9	160	9	160	9	160
	17	0	17	0	1600	0	17	1	17	1	170	17	170	4	170	4	170	4	170	4	170	4	170	4	170	4	170	4	170	4	170
	18	0	18	0	More	0	18	0	18	0	180	18	180	5	180	5	180	5	180	5	180	5	180	5	180	5	180	5	180	5	180
	19	0	19	0	More	0	19	0	19	0	190	19	190	2	190	2	190	2	190	2	190	2	190	2	190	2	190	2	190	2	190
	20	0	20	0	More	0	20	0	20	0	200	20	200	3	200	3	200	3	200	3	200	3	200	3	200	3	200	3	200	3	200
	21	0	21	0	More	0	21	0	21	0	210	21	210	3	210	3	210	3	210	3	210	3	210	3	210	3	210	3	210	3	210
	22	0	22	0	More	0	22	0	22	0	220	22	220	3	220	3	220	3	220	3	220	3	220	3	220	3	220	3	220	3	220
	23	0	23	0	More	0	23	0	23	0	230	23	230	1	230	1	230	1	230	1	230	1	230	1	230	1	230	1	230	1	230
	24	0	24	0	More	0	24	0	24	0	240	24	240	1	240	1	240	1	240	1	240	1	240	1	240	1	240	1	240	1	240
	25	0	25	0	More	0	25	0	25	0	250	25	250	1	250	1	250	1	250	1	250	1	250	1	250	1	250	1	250	1	250
	26	0	26	0	More	0	26	0	26	0	260	26	260	0	260	0	260	0	260	0	260	0	260	0	260	0	260	0	260	0	260
	27	0	27	0	More	0	27	0	27	0	270	27	270	1	270	1	270	1	270	1	270	1	270	1	270	1	270	1	270	1	270
	28	0	28	0	More	0	28	0	28	0	280	28	280	0	280	0	280	0	280	0	280	0	280	0	280	0	280	0	280	0	280
	29	0	29	0	More	0	29	0	29	0	290	29	290	1	290	1	290	1	290	1	290	1	290	1	290	1	290	1	290	1	290
	30	0	30	0	More	0	30	0	30	0	300	30	300	0	300	0	300	0	300	0	300	0	300	0	300	0	300	0	300	0	300
	More	0	More	0	More	0	More	0	More	0	More	More	More	0	More	0	More	0	More	0	More	0	More	0	More	0	More	0	More	0	More

Table B-3. Simulation Results (cont)

Run #	SYSTEM	7	EYIC		Tev	FASz		RsdT		RsdT(C)		MdsR		A/Vap(NT)		A/Vap(NT(C))		MSR		MSNG(C)	
			#	Bin		#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin
A	800	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Start Area		1	0	1	0	50	0	1	0	1	0	10	0	20	0	10	20	0	20	0	
Days	4	2	0	2	0	95	0	2	0	2	0	30	0	30	0	30	20	0	40	0	
Loc Time	2	3	0	3	0	100	0	3	0	3	0	40	0	40	0	40	60	0	60	0	
Rego Time	2	4	0	4	0	127	0	4	0	4	0	50	0	50	0	50	80	0	80	0	
Stop Rules		4	0	4	0	169	0	5	0	6	0	10	0	50	0	50	100	3	100	3	
Stop Time	12	5	0	5	0	205	0	6	0	7	0	20	0	60	3	60	120	4	120	4	
Shrink %	50%	6	6	6	0	225	0	7	24	7	34	70	2	70	2	70	140	3	140	3	
Expand Rules		7	22	7	0	254	0	8	13	80	2	80	6	80	6	80	160	7	160	7	
Expand Time	1.5	8	30	8	14	300	0	9	12	90	5	90	5	90	5	90	180	11	180	11	
5-PI Time	1	9	29	9	41	338	0	10	8	110	6	110	13	110	13	110	200	12	200	12	
Expand %	200%	10	9	10	34	400	0	11	4	120	10	120	18	120	18	120	220	10	220	10	
		11	2	11	8	450	0	12	2	130	9	130	12	130	9	130	240	4	240	4	
		12	0	12	3	600	0	13	2	140	13	140	13	140	13	140	280	10	280	10	
		13	0	13	0	800	0	14	2	150	7	150	8	150	8	150	300	6	300	6	
		14	0	14	0	900	0	15	1	160	3	160	3	160	3	160	320	7	320	7	
		15	0	15	0	1200	0	16	0	170	7	170	7	170	7	170	340	2	340	2	
		16	0	16	0	1600	0	17	0	180	2	180	2	180	2	180	360	2	360	2	
		17	0	17	0	More	0	18	0	190	5	190	5	190	5	190	4	380	4	380	4
		18	0	18	0	More	0	19	0	200	5	200	5	200	5	200	1	400	1	400	1
		19	0	19	0	More	0	20	0	210	2	210	2	210	2	210	1	420	1	420	1
		20	0	20	0	More	0	21	0	220	0	220	0	220	0	220	3	440	3	440	3
		21	0	21	0	More	0	22	0	230	2	230	2	230	2	230	0	460	0	460	0
		22	0	22	0	More	0	23	0	240	1	240	1	240	1	240	0	480	0	480	0
		23	0	23	0	More	0	24	0	250	1	250	1	250	1	250	0	500	1	500	1
		24	0	24	0	More	0	25	0	260	1	260	1	260	1	260	0	520	0	520	0
		25	0	25	0	More	0	26	0	270	1	270	1	270	1	270	0	540	1	540	1
		26	0	26	0	More	0	27	0	280	0	280	0	280	0	280	0	560	0	560	0
		27	0	27	0	More	0	28	0	290	1	290	1	290	1	290	0	580	0	580	0
		28	0	28	0	More	0	29	0	300	0	300	0	300	0	300	0	600	0	600	0
		29	0	29	0	More	0	30	0	310	0	310	0	310	0	310	0	620	0	620	0
		30	0	30	0	More	0	31	0	320	0	320	0	320	0	320	0	640	1	640	1
		More	0	More	0	More	0	32	0	330	0	330	0	330	0	330	0	660	0	660	0
						More	0	33	0	340	0	340	0	340	0	340	0	680	0	680	0
						More	0	34	0	350	0	350	0	350	0	350	0	700	1	700	1
						More	0	35	0	More	0	More	0	More	0	More	3	More	3	More	3

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Run #	SYSTEM	A	EVT	TW		FASZ	RndT		RndT(C)		MDSR	A/(AvgINT)		#	A/(AvgINT(C))		#	MSR		#	MSR(C)		#
				#	Bin		#	Bin	#	Bin		#	Bin		#	Bin		#	Bin		#	Bin	
800																							
Start Area																							
Days	4	1	0	0	1	0	0	0	0	0	0	0	10	0	0	10	0	20	0	20	0	20	0
Loc Time	2	2	0	0	0	95	0	2	0	2	0	20	0	0	0	40	0	40	0	40	0	40	0
Repo Time	2	3	0	0	0	100	0	3	1	3	1	30	0	0	0	30	0	60	0	60	0	60	0
Stop Rules	4	2	4	0	0	127	0	4	0	4	0	40	0	0	0	40	0	80	0	80	0	80	0
Stop Time	12	5	3	5	0	169	0	5	2	5	5	50	0	0	0	50	0	100	0	100	0	100	0
Shrink %	25%	6	8	6	0	200	0	6	21	6	27	60	0	1	30	0	1	120	6	120	2	120	2
Grand Rules	7	36	7	0	0	7	24	7	37	7	37	70	3	1	90	3	1	140	3	140	6	140	6
6-PM Time	1.5	8	21	8	20	254	0	8	18	8	20	80	1	2	80	1	2	160	15	160	13	160	13
5-PM Time	1	9	18	9	47	300	0	9	17	9	6	90	4	3	90	4	3	180	9	180	12	180	12
Expand %	200%	10	10	10	27	338	0	10	4	10	3	100	8	17	100	8	17	200	6	200	6	200	6
		11	11	11	3	400	0	11	6	11	6	110	7	12	110	7	15	220	7	220	7	220	7
		12	0	12	12	4	12	4	12	1	120	11	13	12	120	11	20	240	11	240	11	240	11
		13	1	13	1	600	37	13	1	13	0	130	14	13	130	14	19	260	10	260	9	260	9
		14	0	14	0	800	56	14	0	14	0	140	14	9	140	9	280	8	280	8	280	8	
		15	0	15	0	900	0	15	0	15	0	150	4	8	150	4	300	2	300	2	300	2	
		16	0	16	0	1200	0	16	1	16	0	160	10	8	160	10	320	2	320	2	320	2	
		17	0	17	0	1600	0	17	1	17	0	170	4	1	170	4	340	0	340	0	340	0	
		18	0	18	0	More	0	18	0	18	0	180	4	1	180	4	360	3	360	3	360	3	
		19	0	19	0	More	0	19	0	19	0	190	5	0	190	5	380	3	380	3	380	3	
		20	0	20	0	More	0	20	0	20	0	200	3	0	200	3	400	1	400	1	400	1	
		21	0	21	0	More	0	21	0	21	0	210	2	0	210	2	420	1	420	1	420	1	
		22	0	22	0	More	0	22	0	22	0	220	1	0	220	1	440	0	440	0	440	0	
		23	0	23	0	More	0	23	0	23	0	230	0	0	230	0	460	2	460	2	460	2	
		24	0	24	0	More	0	24	0	24	0	240	2	0	240	2	480	0	480	0	480	0	
		25	0	25	0	More	0	25	0	25	0	250	0	0	250	0	500	0	500	0	500	0	
		26	0	26	0	More	0	26	0	26	0	260	0	0	260	0	520	0	520	0	520	0	
		27	0	27	0	More	0	27	0	27	0	270	1	0	270	1	540	0	540	0	540	0	
		28	0	28	0	More	0	28	0	28	0	280	0	0	280	0	560	0	560	0	560	0	
		29	0	29	0	More	0	29	0	29	0	290	0	0	290	0	580	0	580	0	580	0	
		30	0	30	0	More	0	30	0	30	0	300	0	1	300	0	600	0	600	0	600	0	
		More	0	More	0	More	0	More	0	More	0	310	1	0	310	1	620	1	620	1	620	1	
												320	1	0	320	1	640	0	640	0	640	0	
												330	0	0	330	0	660	0	660	0	660	0	
												340	0	0	340	0	680	0	680	0	680	0	
												350	0	0	350	0	700	0	700	0	700	0	
												More	0	0	More	0	More	4	More	4	More	4	

Table B-3. Simulation Results (cont)

Table B-3. Simulation Results (cont)

Run #	SYSTEM	Start Area	Days	Loc Time	Repo Time	Stop Rules	Shrink %	Expand Rules	6-PI Time	5-PI Time	Expand %							
11	A	800	4	4	2	20	50%	1.5	1	200%								
EvTC	#	Bin	Tev	#	FAStz	#	RedT	#	RedT(C)	#	MSR	#	A/Avg(NT)	#	MSR	#	MSR(C)	#
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	1	0	0	50	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	2	0	0	95	0	0	0	0	0	0	0	0	0	0	0	0	0
3	2	3	0	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0
4	4	4	1	127	0	4	2	4	12	50	4	1	50	4	1	100	5	100
5	10	5	6	169	0	5	13	5	13	60	4	1	60	4	1	120	4	120
6	24	6	21	200	0	6	19	6	19	70	5	2	70	5	2	140	7	140
7	33	7	42	225	0	7	17	7	17	80	6	3	80	6	3	160	8	160
8	20	8	21	254	0	8	16	8	16	90	7	4	90	7	4	180	9	180
9	6	9	6	300	0	9	11	9	11	100	8	5	100	8	5	200	10	200
10	1	10	1	336	0	10	6	10	6	110	12	11	110	12	11	220	13	220
11	0	11	0	400	0	11	5	11	5	120	9	130	120	9	130	240	12	240
12	0	12	0	450	0	12	3	12	3	130	10	140	130	10	140	280	13	280
13	0	13	0	600	0	13	1	13	1	140	10	150	140	10	150	300	14	300
14	0	14	0	800	97	14	1	14	1	150	5	160	150	5	160	320	15	320
15	0	15	0	900	0	15	1	15	1	160	5	170	160	5	170	340	16	340
16	0	16	0	1200	0	16	2	16	2	170	6	180	170	6	180	360	17	360
17	0	17	0	1600	0	17	1	17	1	180	7	190	180	7	190	380	18	380
18	0	18	0	More	0	18	0	18	0	200	4	200	200	4	200	400	19	400
19	0	19	0	20	0	19	0	19	0	210	3	210	210	3	210	420	20	420
20	0	20	0	20	0	20	0	20	0	220	1	220	220	1	220	440	21	440
21	0	21	0	20	0	21	0	21	0	230	1	230	230	1	230	460	22	460
22	0	22	0	20	0	22	0	22	0	240	0	240	240	0	240	480	23	480
23	0	23	0	20	0	23	0	23	0	250	4	250	250	4	250	500	24	500
24	0	24	0	20	0	24	0	24	0	260	1	260	260	1	260	520	25	520
25	0	25	0	20	0	25	0	25	0	270	0	270	270	0	270	540	26	540
26	0	26	0	20	0	26	0	26	0	280	0	280	280	0	280	560	27	560
27	0	27	0	20	0	27	0	27	0	290	0	290	290	0	290	580	28	580
28	0	28	0	20	0	28	0	28	0	300	0	300	300	0	300	600	29	600
29	0	29	0	20	0	29	0	29	0	310	2	310	310	2	310	620	30	620
30	0	30	0	20	0	30	0	30	0	320	0	320	320	0	320	640	31	640
More	0	More	0	More	0	More	0	More	0	330	0	330	330	0	330	660	32	660
More	0	More	0	More	0	More	0	More	0	340	0	340	340	0	340	680	33	680
More	0	More	0	More	0	More	0	More	0	350	0	350	350	0	350	700	34	700
More	0	More	0	More	0	More	0	More	0	More	1	More	More	1	More	More	35	More

Run #	SYSTEM	Start Area	Days	Loc Time	Repo Time	Stop Rules	Shrink %	Expand Rules	6-PI Time	5-PI Time	Expand %	EvTC		Tev		FASz		RndT		RndT(C)		MSDR		A/Avg(NT)		A/Avg(RT(C))		MSR		MSR(C)	
												#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin
12	153	800	4	4	2	20	25%	1.5	1	200%		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
												1	0	1	0	0	50	0	0	0	0	10	0	10	0	10	0	20	0	20	0
												2	0	2	0	95	0	0	0	0	20	0	20	0	20	0	40	0	40	0	
												3	1	3	0	100	0	3	1	30	0	30	0	30	0	30	0	60	0	60	0
												4	6	4	0	127	0	4	0	40	0	40	0	40	0	40	0	80	1	80	1
												5	10	5	0	169	0	5	12	50	1	50	1	50	1	50	1	100	5	100	5
												6	25	6	22	200	0	6	21	60	2	60	2	60	2	60	2	120	4	120	4
												7	35	7	44	225	0	7	22	70	3	70	3	70	3	70	3	140	8	140	8
												8	19	8	19	254	0	8	14	80	2	80	2	80	2	80	2	160	6	160	6
												9	4	9	4	300	0	9	9	90	3	90	3	90	3	90	3	180	8	180	8
												10	1	10	1	338	0	10	9	100	6	100	6	100	6	100	6	200	7	200	7
												11	0	11	0	400	0	11	4	110	10	110	10	110	10	110	10	220	10	220	9
												12	0	12	0	450	0	12	3	120	8	120	8	120	8	120	8	240	12	240	13
												13	0	13	0	600	3	13	1	130	11	130	11	130	11	130	11	260	7	260	7
												14	0	14	0	800	97	14	2	140	10	140	10	140	10	140	10	280	5	280	5
												15	0	15	0	900	0	15	0	150	5	150	5	150	5	150	5	300	4	300	4
												16	0	16	0	1200	0	16	1	160	3	160	3	160	3	160	3	320	3	320	3
												17	0	17	0	1600	0	17	0	170	7	170	7	170	7	170	7	340	2	340	2
												18	0	18	0	More	0	18	0	180	4	180	4	180	4	180	4	360	2	360	2
												19	0	19	0	More	0	19	1	190	4	190	4	190	4	190	4	380	3	380	3
												20	0	20	0	More	0	20	0	200	4	200	4	200	4	200	4	400	2	400	2
												21	0	21	0	More	0	21	0	210	2	210	2	210	2	210	2	420	2	420	2
												22	0	22	0	More	0	22	2	220	2	220	2	220	2	220	2	440	1	440	1
												23	0	23	0	More	0	23	1	230	0	230	0	230	0	230	0	460	0	460	0
												24	0	24	0	More	0	24	0	240	0	240	0	240	0	240	0	480	1	480	1
												25	0	25	0	More	0	25	2	250	0	250	0	250	0	250	0	500	3	500	3
												26	0	26	0	More	0	26	0	260	0	260	0	260	0	260	0	520	0	520	0
												27	0	27	0	More	0	27	0	270	0	270	0	270	0	270	0	540	1	540	1
												28	0	28	0	More	0	28	0	280	1	280	1	280	1	280	1	560	0	560	0
												29	0	29	0	More	0	29	0	290	0	290	0	290	0	290	0	580	0	580	0
												30	0	30	0	More	0	30	0	300	0	300	0	300	0	300	0	600	3	600	3
												More	0	More	0	More	0	More	0	310	1	310	1	310	1	310	1	620	0	620	0
												More	0	More	0	More	0	More	0	320	0	320	0	320	0	320	0	640	0	640	0
												More	0	More	0	More	0	More	0	330	0	330	0	330	0	330	0	660	0	660	0
												More	0	More	0	More	0	More	0	340	0	340	0	340	0	340	0	680	0	680	0
												More	0	More	0	More	0	More	0	350	0	350	0	350	0	350	0	700	1	700	1
												More	0	More	0	More	0	More	2	More	0	More	0	More	0	More	0	More	3	More	3

Table B-3. Simulation Results (cont)

Run #	SYSTEM	Start Area	Days	Loc Time	Rego Time	Stop Rules	Stop Time	Shrink %	Expand Rules	6-Pr Time	5-Pr Time	Expand %	EvTC		Tev		FASz		RndT		RndT(C)		MdsR		AAvg(NT)		A/Avg(NTC)		MSR		MSR(C)	
													Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#
13	A	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
4	1	0	1	0	95	0	2	0	1	0	1	0	10	0	10	0	10	0	20	0	20	0	20	0	20	0	20	0	20	0	20	
4	2	0	2	0	95	0	2	0	1	0	1	0	20	0	20	0	20	0	40	0	40	0	40	0	40	0	40	0	40	0	40	
2	3	0	3	0	100	0	3	0	3	0	3	0	30	0	30	0	30	0	60	0	60	0	60	0	60	0	60	0	60	0	60	
4	4	8	4	0	127	0	4	3	4	3	4	0	40	0	40	0	40	0	80	3	80	3	80	3	80	3	80	3	80	3	80	
18	5	9	5	3	169	0	5	12	5	13	50	0	50	0	50	0	50	0	100	5	100	5	100	5	100	5	100	5	100	5	100	
50%	6	29	6	22	200	1	6	16	6	16	60	3	60	2	60	2	60	2	120	6	120	6	120	6	120	6	120	6	120	6	120	
1.5	7	28	7	42	225	0	7	19	7	24	70	3	70	4	70	4	70	4	140	4	140	4	140	4	140	4	140	4	140	4	140	
200%	8	17	8	25	254	0	8	17	8	18	80	5	80	7	80	7	80	7	160	10	160	10	160	10	160	10	160	10	160	10	160	
	9	7	9	8	300	0	9	11	9	11	90	2	90	9	90	9	90	9	180	9	180	9	180	9	180	9	180	9	180	9	180	
	10	0	10	0	338	0	10	9	10	6	100	6	100	11	100	11	100	11	200	7	200	7	200	7	200	7	200	7	200	7	200	
	11	0	11	0	400	9	11	4	11	4	110	9	110	12	110	12	110	12	220	6	220	6	220	6	220	6	220	6	220	6	220	
	12	0	12	0	450	0	12	6	12	3	120	7	120	10	120	10	120	10	240	7	240	7	240	7	240	7	240	7	240	7	240	
	13	0	13	0	800	0	13	1	13	2	130	10	130	14	130	14	130	14	280	5	280	5	280	5	280	5	280	5	280	5	280	
	14	0	14	0	900	0	14	1	14	0	140	6	140	4	140	4	140	4	260	6	260	6	260	6	260	6	260	6	260	6	260	
	15	0	15	0	900	0	15	0	15	0	150	9	150	9	150	9	150	9	300	6	300	6	300	6	300	6	300	6	300	6	300	
	16	0	16	0	1200	0	16	1	16	0	160	8	160	8	160	8	160	8	320	5	320	5	320	5	320	5	320	5	320	5	320	
	17	0	17	0	1600	0	17	0	17	0	170	5	170	4	170	4	170	4	340	3	340	3	340	3	340	3	340	3	340	3	340	
	18	0	18	0	1800	0	18	0	18	0	180	4	180	4	180	4	180	4	360	1	360	1	360	1	360	1	360	1	360	1	360	
	19	0	19	0	1900	0	19	0	19	0	190	6	190	2	190	2	190	2	380	1	380	1	380	1	380	1	380	1	380	1	380	
	20	0	20	0	2000	0	20	0	20	0	200	2	200	2	200	2	200	2	400	3	400	3	400	3	400	3	400	3	400	3	400	
	21	0	21	0	2100	0	21	0	21	0	210	6	210	1	210	1	210	1	420	2	420	2	420	2	420	2	420	2	420	2	420	
	22	0	22	0	2200	0	22	0	22	0	220	2	220	2	220	2	220	2	440	1	440	1	440	1	440	1	440	1	440	1	440	
	23	0	23	0	2300	0	23	0	23	0	230	1	230	0	230	0	230	0	460	0	460	0	460	0	460	0	460	0	460	0	460	
	24	0	24	0	2400	0	24	0	24	0	240	0	240	1	240	1	240	1	480	2	480	2	480	2	480	2	480	2	480	2	480	
	25	0	25	0	2500	0	25	0	25	0	250	2	250	0	250	0	250	0	500	2	500	2	500	2	500	2	500	2	500	2	500	
	26	0	26	0	2600	0	26	0	26	0	260	1	260	0	260	0	260	0	520	1	520	1	520	1	520	1	520	1	520	1	520	
	27	0	27	0	2700	0	27	0	27	0	270	0	270	0	270	0	270	0	540	1	540	1	540	1	540	1	540	1	540	1	540	
	28	0	28	0	2800	0	28	0	28	0	280	1	280	0	280	0	280	0	560	0	560	0	560	0	560	0	560	0	560	0	560	
	29	0	29	0	2900	0	29	0	29	0	290	0	290	0	290	0	290	0	580	1	580	1	580	1	580	1	580	1	580	1	580	
	30	0	30	0	3000	0	30	0	30	0	300	0	300	0	300	0	300	0	600	0	600	0	600	0	600	0	600	0	600	0	600	
	More	U	More	U	More	U	More	U	More	U	More	U	More	U	More	U	More	U	640	0	640	0	640	0	640	0	640	0	640	0	640	

Run #	SYSTEM	A	EUTC		Tev		FASz		RndT		RndT(C)		MSR		A/Avg(NT)		A/Avg(NT(C))		MSR		MSR(C)	
			#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin
14			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
800			1	0	1	0	50	0	1	0	1	0	10	0	10	0	10	0	20	0	20	
4			2	0	2	0	95	0	2	0	2	0	20	0	20	0	20	0	40	0	40	
4			3	1	3	0	100	0	3	0	3	0	30	0	30	0	30	0	60	0	60	
2			4	6	4	0	127	0	4	3	4	3	40	0	40	0	40	0	80	2	80	
18			5	15	5	1	169	0	5	15	5	15	50	0	50	0	50	0	100	2	100	
25%			6	23	6	22	200	0	6	16	6	16	60	3	60	0	60	0	120	6	120	
			7	28	7	43	225	0	7	17	7	22	70	3	70	0	70	0	140	7	140	
1.5			8	17	8	24	254	0	8	16	8	14	80	5	80	0	80	0	160	8	160	
6-Pr Time			9	9	9	9	300	0	9	12	9	15	90	5	90	0	90	0	180	9	180	
8-Pr Time			10	1	10	1	400	0	10	9	10	8	100	6	100	0	100	0	200	6	200	
Expand %			11	0	11	0	450	0	11	6	11	3	110	6	110	0	110	0	220	5	220	
			12	0	12	0	450	0	12	3	12	3	120	10	120	0	120	0	240	5	240	
			13	0	13	0	600	11	13	4	13	1	130	12	130	0	130	0	260	9	260	
			14	0	14	0	800	89	14	0	14	0	140	6	140	0	140	0	280	6	280	
			15	0	15	0	900	0	15	0	15	0	150	5	150	0	150	0	300	4	300	
			16	0	16	0	1200	0	16	0	16	0	160	7	160	0	160	0	320	6	320	
			17	0	17	0	1600	0	17	1	17	0	170	5	170	0	170	0	340	3	340	
			18	0	18	0	More	0	18	0	18	0	180	4	180	0	180	0	360	3	360	
			19	0	19	0	More	0	19	0	19	0	190	5	190	0	190	0	380	3	380	
			20	0	20	0	More	0	20	0	20	0	200	1	200	0	200	0	400	3	400	
			21	0	21	0	More	0	21	0	21	0	210	5	210	0	210	0	420	1	420	
			22	0	22	0	More	0	22	0	22	0	220	3	220	0	220	0	440	1	440	
			23	0	23	0	More	0	23	0	23	0	230	2	230	0	230	0	460	0	460	
			24	0	24	0	More	0	24	0	24	0	240	0	240	0	240	0	480	2	480	
			25	0	25	0	More	0	25	0	25	0	250	4	250	0	250	0	500	3	500	
			26	0	26	0	More	0	26	0	26	0	260	0	260	0	260	0	520	2	520	
			27	0	27	0	More	0	27	0	27	0	270	0	270	0	270	0	540	0	540	
			28	0	28	0	More	0	28	0	28	0	280	0	280	0	280	0	560	0	560	
			29	0	29	0	More	0	29	0	29	0	290	0	290	0	290	0	580	1	580	
			30	0	30	0	More	0	30	0	30	0	300	0	300	0	300	0	600	0	600	
More			More	0	More	0	More	0	More	0	More	0	310	1	310	0	310	0	620	0	620	
			More	0	More	0	More	0	More	0	More	0	320	0	320	0	320	0	640	0	640	
			More	0	More	0	More	0	More	0	More	0	330	0	330	0	330	0	660	0	660	
			More	0	More	0	More	0	More	0	More	0	340	0	340	0	340	0	680	0	680	
			More	0	More	0	More	0	More	0	More	0	350	0	350	0	350	0	700	0	700	
			More	0	More	0	More	0	More	0	More	0	More	0	More	0	More	0	More	4	More	

Table B-3. Simulation Results (cont)

Table B-3. Simulation Results (cont)

Run #	SYSTEM	Start Area	Days	Loc Time	Rego Time	Stop Rules	Stop Time	Shrink %	Expand Rules	6-Pr Time	8-Pr Time	Expand %	EvTC	Tev	FASZ	RedT	RedT(C)	MSR	AAvg(NT)	MSR	MSR(C)	#
17	A	800	4	2	3	5	3	20	4	20	127	0	4	7	4	4	0	0	0	0	0	0
18	A	800	4	2	3	5	3	20	4	20	127	0	4	7	4	4	0	0	0	0	0	0
19	A	800	4	2	3	5	3	20	4	20	127	0	4	7	4	4	0	0	0	0	0	0
20	A	800	4	2	3	5	3	20	4	20	127	0	4	7	4	4	0	0	0	0	0	0
21	A	800	4	2	3	5	3	20	4	20	127	0	4	7	4	4	0	0	0	0	0	0
22	A	800	4	2	3	5	3	20	4	20	127	0	4	7	4	4	0	0	0	0	0	0
23	A	800	4	2	3	5	3	20	4	20	127	0	4	7	4	4	0	0	0	0	0	0
24	A	800	4	2	3	5	3	20	4	20	127	0	4	7	4	4	0	0	0	0	0	0
25	A	800	4	2	3	5	3	20	4	20	127	0	4	7	4	4	0	0	0	0	0	0
26	A	800	4	2	3	5	3	20	4	20	127	0	4	7	4	4	0	0	0	0	0	0
27	A	800	4	2	3	5	3	20	4	20	127	0	4	7	4	4	0	0	0	0	0	0
28	A	800	4	2	3	5	3	20	4	20	127	0	4	7	4	4	0	0	0	0	0	0
29	A	800	4	2	3	5	3	20	4	20	127	0	4	7	4	4	0	0	0	0	0	0
30	A	800	4	2	3	5	3	20	4	20	127	0	4	7	4	4	0	0	0	0	0	0
More																						
17	A	800	4	2	3	5	3	20	4	20	127	0	4	7	4	4	0	0	0	0	0	0
18	A	800	4	2	3	5	3	20	4	20	127	0	4	7	4	4	0	0	0	0	0	0
19	A	800	4	2	3	5	3	20	4	20	127	0	4	7	4	4	0	0	0	0	0	0
20	A	800	4	2	3	5	3	20	4	20	127	0	4	7	4	4	0	0	0	0	0	0
21	A	800	4	2	3	5	3	20	4	20	127	0	4	7	4	4	0	0	0	0	0	0
22	A	800	4	2	3	5	3	20	4	20	127	0	4	7	4	4	0	0	0	0	0	0
23	A	800	4	2	3	5	3	20	4	20	127	0	4	7	4	4	0	0	0	0	0	0
24	A	800	4	2	3	5	3	20	4	20	127	0	4	7	4	4	0	0	0	0	0	0
25	A	800	4	2	3	5	3	20	4	20	127	0	4	7	4	4	0	0	0	0	0	0
26	A	800	4	2	3	5	3	20	4	20	127	0	4	7	4	4	0	0	0	0	0	0
27	A	800	4	2	3	5	3	20	4	20	127	0	4	7	4	4	0	0	0	0	0	0
28	A	800	4	2	3	5	3	20	4	20	127	0	4	7	4	4	0	0	0	0	0	0
29	A	800	4	2	3	5	3	20	4	20	127	0	4	7	4	4	0	0	0	0	0	0
30	A	800	4	2	3	5	3	20	4	20	127	0	4	7	4	4	0	0	0	0	0	0
More																						

Table B-3. Simulation Results (cont)

Run #	SYSTEM	Start Area	Days	Loc Time	Reps Time	Stop Rules	Stop Time	Shrink %	Expand Rules	6-PI Time	Expand %
19	A	800	4	2	3	5	42	53	200	0	200%
20	A	800	4	2	3	5	42	53	200	0	200%
21	A	800	4	2	3	5	42	53	200	0	200%
22	A	800	4	2	3	5	42	53	200	0	200%
23	A	800	4	2	3	5	42	53	200	0	200%
24	A	800	4	2	3	5	42	53	200	0	200%
25	A	800	4	2	3	5	42	53	200	0	200%
26	A	800	4	2	3	5	42	53	200	0	200%
27	A	800	4	2	3	5	42	53	200	0	200%
28	A	800	4	2	3	5	42	53	200	0	200%
29	A	800	4	2	3	5	42	53	200	0	200%
30	A	800	4	2	3	5	42	53	200	0	200%
31	A	800	4	2	3	5	42	53	200	0	200%
32	A	800	4	2	3	5	42	53	200	0	200%
33	A	800	4	2	3	5	42	53	200	0	200%
34	A	800	4	2	3	5	42	53	200	0	200%
35	A	800	4	2	3	5	42	53	200	0	200%
36	A	800	4	2	3	5	42	53	200	0	200%
37	A	800	4	2	3	5	42	53	200	0	200%
38	A	800	4	2	3	5	42	53	200	0	200%
39	A	800	4	2	3	5	42	53	200	0	200%
40	A	800	4	2	3	5	42	53	200	0	200%
41	A	800	4	2	3	5	42	53	200	0	200%
42	A	800	4	2	3	5	42	53	200	0	200%
43	A	800	4	2	3	5	42	53	200	0	200%
44	A	800	4	2	3	5	42	53	200	0	200%
45	A	800	4	2	3	5	42	53	200	0	200%
46	A	800	4	2	3	5	42	53	200	0	200%
47	A	800	4	2	3	5	42	53	200	0	200%
48	A	800	4	2	3	5	42	53	200	0	200%
49	A	800	4	2	3	5	42	53	200	0	200%
50	A	800	4	2	3	5	42	53	200	0	200%
51	A	800	4	2	3	5	42	53	200	0	200%
52	A	800	4	2	3	5	42	53	200	0	200%
53	A	800	4	2	3	5	42	53	200	0	200%
54	A	800	4	2	3	5	42	53	200	0	200%
55	A	800	4	2	3	5	42	53	200	0	200%
56	A	800	4	2	3	5	42	53	200	0	200%
57	A	800	4	2	3	5	42	53	200	0	200%
58	A	800	4	2	3	5	42	53	200	0	200%
59	A	800	4	2	3	5	42	53	200	0	200%
60	A	800	4	2	3	5	42	53	200	0	200%
61	A	800	4	2	3	5	42	53	200	0	200%
62	A	800	4	2	3	5	42	53	200	0	200%
63	A	800	4	2	3	5	42	53	200	0	200%
64	A	800	4	2	3	5	42	53	200	0	200%
65	A	800	4	2	3	5	42	53	200	0	200%
66	A	800	4	2	3	5	42	53	200	0	200%
67	A	800	4	2	3	5	42	53	200	0	200%
68	A	800	4	2	3	5	42	53	200	0	200%
69	A	800	4	2	3	5	42	53	200	0	200%
70	A	800	4	2	3	5	42	53	200	0	200%
71	A	800	4	2	3	5	42	53	200	0	200%
72	A	800	4	2	3	5	42	53	200	0	200%
73	A	800	4	2	3	5	42	53	200	0	200%
74	A	800	4	2	3	5	42	53	200	0	200%
75	A	800	4	2	3	5	42	53	200	0	200%
76	A	800	4	2	3	5	42	53	200	0	200%
77	A	800	4	2	3	5	42	53	200	0	200%
78	A	800	4	2	3	5	42	53	200	0	200%
79	A	800	4	2	3	5	42	53	200	0	200%
80	A	800	4	2	3	5	42	53	200	0	200%
81	A	800	4	2	3	5	42	53	200	0	200%
82	A	800	4	2	3	5	42	53	200	0	200%
83	A	800	4	2	3	5	42	53	200	0	200%
84	A	800	4	2	3	5	42	53	200	0	200%
85	A	800	4	2	3	5	42	53	200	0	200%
86	A	800	4	2	3	5	42	53	200	0	200%
87	A	800	4	2	3	5	42	53	200	0	200%
88	A	800	4	2	3	5	42	53	200	0	200%
89	A	800	4	2	3	5	42	53	200	0	200%
90	A	800	4	2	3	5	42	53	200	0	200%
91	A	800	4	2	3	5	42	53	200	0	200%
92	A	800	4	2	3	5	42	53	200	0	200%
93	A	800	4	2	3	5	42	53	200	0	200%
94	A	800	4	2	3	5	42	53	200	0	200%
95	A	800	4	2	3	5	42	53	200	0	200%
96	A	800	4	2	3	5	42	53	200	0	200%
97	A	800	4	2	3	5	42	53	200	0	200%
98	A	800	4	2	3	5	42	53	200	0	200%
99	A	800	4	2	3	5	42	53	200	0	200%
100	A	800	4	2	3	5	42	53	200	0	200%

Table B-3. Simulation Results (cont)

Table B-3. Simulation Results (cont)

[illegible]

Run #	24	EVT		Tev		FASz		RndT		RndT(C)		MSR		AAvg(N(T))		MSR		AAvg(N(T))		MSR		MSR(C)	
		#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin
SYSTEM	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Start Area	800	1	0	1	0	0	50	0	1	0	1	0	10	0	10	0	20	0	10	0	20	0	0
Days	4	1	0	1	0	0	0	0	0	0	2	0	20	0	20	0	40	0	40	0	40	0	0
Loc Time	8	2	0	2	0	0	95	0	2	0	2	30	0	30	0	60	0	60	0	60	0	0	
Rego Time	2	3	6	3	0	100	0	3	2	3	4	40	0	40	0	80	0	80	0	80	0	0	
Stop Rules	4	4	25	4	0	127	0	4	12	4	5	14	50	0	50	0	100	5	100	2	2	2	
Stop Time	12	5	44	5	18	169	0	5	12	6	22	60	2	60	1	120	6	120	6	120	6	9	
Shrink %	25%	6	21	6	74	200	0	7	17	7	26	70	4	70	5	70	4	140	8	140	9	10	
Expand Rules	1.5	7	4	7	8	225	0	8	14	8	13	80	5	80	8	160	10	160	10	160	10	9	
6-PT Time	1	8	0	8	0	254	0	9	13	9	10	90	3	90	10	180	6	180	6	180	6	6	
8-PT Time	200%	9	0	9	0	300	0	10	13	10	8	100	4	100	12	200	8	200	13	200	13	13	
Expand %		10	0	10	0	338	0	11	5	11	1	120	6	120	15	240	7	240	5	240	5	5	
		11	0	11	0	400	0	12	5	12	0	130	10	130	16	260	3	260	5	260	5	5	
		12	0	12	0	450	5	13	3	13	0	140	8	140	7	140	11	280	8	280	8	8	
		13	0	13	0	600	19	14	14	14	0	150	5	150	5	300	5	300	5	300	5	5	
		14	0	14	0	800	76	15	1	15	0	160	6	160	6	320	2	320	2	320	2	2	
		15	0	15	0	900	0	16	1	16	0	170	4	170	3	340	1	340	1	340	1	1	
		16	0	16	0	1200	0	17	0	17	0	180	3	180	4	360	4	360	4	360	4	4	
		17	0	17	0	1600	0	18	0	18	0	190	1	190	3	380	1	380	1	380	1	1	
		18	0	18	0	More	0	19	0	19	0	200	4	200	3	400	1	400	1	400	1	1	
		19	0	19	0	More	0	20	0	20	0	210	5	210	1	420	1	420	1	420	1	1	
		20	0	20	0	More	0	21	0	21	0	220	5	220	0	440	2	440	2	440	2	3	
		21	0	21	0	More	0	22	0	22	0	230	4	230	3	460	2	460	2	460	2	1	
		22	0	22	0	More	0	23	0	23	0	240	0	240	3	480	0	480	0	480	0	1	
		23	0	23	0	More	0	24	0	24	0	250	0	250	0	500	0	500	0	500	0	0	
		24	0	24	0	More	0	25	0	25	0	260	1	260	0	520	0	520	0	520	0	0	
		25	0	25	0	More	0	26	0	26	0	270	0	270	0	540	0	540	0	540	0	0	
		26	0	26	0	More	0	27	0	27	0	280	1	280	0	560	2	560	2	560	2	2	
		27	0	27	0	More	0	28	0	28	0	290	0	290	1	580	2	580	2	580	2	2	
		28	0	28	0	More	0	29	0	29	0	300	2	300	0	600	1	600	1	600	1	1	
		29	0	29	0	More	0	30	0	30	0	310	2	310	1	620	0	620	0	620	0	0	
		30	0	30	0	More	0	31	0	31	0	320	0	320	0	640	0	640	0	640	0	0	
		More	U	More	U	More	U	More	U	More	U	330	0	330	0	660	0	660	0	660	0	0	
		More	U	More	U	More	U	More	U	More	U	340	0	340	0	680	1	680	1	680	1	1	
		More	U	More	U	More	U	More	U	More	U	350	0	350	0	700	5	700	5	700	5	5	
		More	U	More	U	More	U	More	U	More	U	More	U	More	U	More	U	More	U	More	U	More	

Table B-3. Simulation Results (cont)

Run #	EvTC	Tev	FASz	RndT	RndT(C)	MSR	A/Avg(NT)	MSR	MSRC	#
25	Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin
SYSTEM	0	0	0	0	0	0	0	0	0	0
Start Area	0	0	0	0	0	0	0	0	0	0
Days	1	0	50	1	0	10	10	20	20	0
Loc Time	2	0	95	0	2	30	20	40	40	0
Repo Time	3	0	100	0	3	30	30	60	60	0
Stop Rules	4	0	127	0	4	40	40	80	80	0
Shrink %	5	0	169	0	5	50	50	100	100	0
Expand Rules	6	0	200	0	6	60	60	120	120	2
5-PI Time	7	0	225	0	7	70	70	140	140	5
Expand %	8	0	254	0	8	80	80	160	160	10
1	9	0	300	0	9	90	90	180	180	5
200%	10	0	338	0	10	100	100	200	200	9
	11	1	400	5	11	110	110	220	220	17
	12	2	450	12	12	120	120	240	240	12
	13	2	500	13	13	130	130	260	260	7
	14	14	600	14	14	140	140	280	280	8
	15	15	800	15	15	150	150	300	300	4
	16	16	900	16	16	160	160	320	320	3
	17	17	1200	17	17	170	170	340	340	4
	18	18	1600	18	18	180	180	360	360	4
	19	19	More	19	19	190	190	380	380	4
	20	20	More	20	20	200	200	400	400	1
	21	21	More	21	21	210	210	420	420	0
	22	22	More	22	22	220	220	440	440	1
	23	23	More	23	23	230	230	460	460	1
	24	24	More	24	24	240	240	480	480	1
	25	25	More	25	25	250	250	500	500	0
	26	26	More	26	26	260	260	520	520	3
	27	27	More	27	27	270	270	540	540	1
	28	28	More	28	28	280	280	560	560	0
	29	29	More	29	29	290	290	580	580	0
	30	30	More	30	30	300	300	600	600	0
	More	More	More	More	More	310	310	620	620	0
						320	320	640	640	1
						330	330	660	660	0
						340	340	680	680	0
						350	350	700	700	0
						More	More	More	More	1

Run #	EvTC	Tev	FASz	RndT	RndT(C)	MSR	A/Avg(NT)	MSR	MSRC	#
26	Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin
SYSTEM	0	0	0	0	0	0	0	0	0	0
Start Area	0	0	0	0	0	0	0	0	0	0
Days	1	0	50	1	0	10	10	20	20	0
Loc Time	2	0	95	0	2	30	20	40	40	0
Repo Time	3	0	100	0	3	30	30	60	60	0
Stop Rules	4	0	127	0	4	40	40	80	80	0
Shrink %	5	0	169	0	5	50	50	100	100	0
Expand Rules	6	0	200	0	6	60	60	120	120	2
5-PI Time	7	0	225	0	7	70	70	140	140	7
Expand %	8	0	254	0	8	80	80	160	160	6
1	9	0	300	0	9	90	90	180	180	10
200%	10	0	338	0	10	100	100	200	200	11
	11	1	400	11	11	110	110	220	220	12
	12	2	450	12	12	120	120	240	240	11
	13	13	600	13	13	130	130	260	260	7
	14	14	800	14	14	140	140	280	280	3
	15	15	900	15	15	150	150	300	300	3
	16	16	1200	16	16	160	160	320	320	3
	17	17	1600	17	17	170	170	340	340	4
	18	18	More	18	18	180	180	360	360	4
	19	19	More	19	19	190	190	380	380	3
	20	20	More	20	20	200	200	400	400	2
	21	21	More	21	21	210	210	420	420	2
	22	22	More	22	22	220	220	440	440	2
	23	23	More	23	23	230	230	460	460	1
	24	24	More	24	24	240	240	480	480	1
	25	25	More	25	25	250	250	500	500	0
	26	26	More	26	26	260	260	520	520	2
	27	27	More	27	27	270	270	540	540	1
	28	28	More	28	28	280	280	560	560	0
	29	29	More	29	29	290	290	580	580	0
	30	30	More	30	30	300	300	600	600	0
	More	More	More	More	More	310	310	620	620	0
						320	320	640	640	1
						330	330	660	660	0
						340	340	680	680	0
						350	350	700	700	0
						More	More	More	More	1

Table B-3. Simulation Results (cont)

Run #	SYSTEM	27	EUTC		Tev	FASz	RndT		RndT(C)		MedSR		AAvg(MT)		AAvg(MT(C))		MSR		MSRC	
			#	Bin			#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin
A	Start Area	800	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B	Days	1	0	0	1	0	50	0	1	0	10	0	10	0	10	0	20	0	20	0
2	Loc Time	2	0	2	0	95	0	2	0	2	20	0	20	0	20	0	40	0	40	0
2	Repo Time	3	0	3	0	100	0	3	0	3	30	0	30	0	30	0	60	0	60	0
20	Stop Rules	4	0	4	0	127	0	4	0	4	40	0	40	0	40	0	80	0	80	0
50%	Stop Time	5	0	5	0	169	0	5	1	5	50	0	50	0	50	0	100	0	100	0
1	Shrink %	6	0	6	0	225	0	6	11	6	60	0	60	0	60	0	120	2	120	2
1.5	Expand Rules	7	0	7	0	200	0	7	23	7	70	2	70	3	70	7	140	7	140	7
6-PM Time	Expand %	8	0	8	0	254	0	8	24	8	80	1	80	3	80	8	160	6	160	6
200%		9	0	9	0	300	0	9	20	9	90	3	90	10	90	9	180	8	180	8
		10	0	10	0	338	0	10	10	10	100	10	100	20	100	10	200	10	200	10
		11	2	11	0	400	13	11	3	12	110	13	110	18	110	12	220	12	220	12
		12	2	12	0	450	0	12	3	12	120	9	120	17	120	21	240	12	240	12
		13	5	13	5	600	0	13	0	13	130	13	130	14	130	15	260	5	260	5
		14	8	14	4	800	87	14	0	14	140	14	140	8	140	10	280	7	280	7
		15	17	15	13	900	0	15	0	15	150	8	150	9	150	9	300	9	300	9
		16	23	16	22	1200	0	16	0	16	160	12	160	1	160	1	320	2	320	2
		17	19	17	17	1600	0	17	0	17	170	7	170	1	170	1	340	4	340	4
		18	12	18	16	None	0	18	0	18	180	3	180	U	180	U	360	4	360	4
		19	9	19	13	None	0	19	0	19	190	2	190	0	190	0	380	2	380	2
		20	2	20	3	None	0	20	0	20	200	0	200	0	200	0	400	1	400	1
		21	1	21	0	None	U	21	0	21	210	U	210	U	210	U	420	2	420	2
		22	0	22	1	None	U	22	0	22	220	0	220	0	220	0	440	0	440	0
		23	0	23	0	None	U	23	0	23	230	0	230	0	230	0	460	0	460	0
		24	0	24	0	None	U	24	0	24	240	2	240	0	240	0	480	0	480	0
		25	0	25	0	None	U	25	0	25	250	1	250	0	250	0	500	2	500	2
		26	0	26	0	None	U	26	0	26	260	0	260	0	260	0	520	2	520	2
		27	0	27	0	None	U	27	0	27	270	0	270	0	270	0	540	0	540	0
		28	0	28	0	None	U	28	0	28	280	0	280	0	280	0	560	1	560	1
		29	0	29	0	None	U	29	0	29	290	0	290	0	290	0	580	0	580	0
		30	0	30	0	None	U	30	0	30	300	0	300	0	300	0	600	0	600	0
None			U	More	U						310	U	310	U	310	U	620	0	620	0
											320	0	320	0	320	0	640	0	640	0
											330	0	330	0	330	0	660	0	660	0
											340	0	340	0	340	0	680	0	680	0
											350	U	350	U	350	U	700	0	700	0
											More	U	More	U	More	U	1	More	1	More

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[illegible]

Table B-3. Simulation Results (cont)

Run #	SYSTEM	EVT		Tev		FASZ		RndT		MSDR		A/Avg(MT)		MSR		MSR(C)	
		Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#
29	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
800	Start Area	1	0	1	0	50	0	1	0	10	0	10	0	20	0	20	0
8	Days	2	0	2	0	95	0	2	0	30	0	30	0	40	0	40	0
2	Loc Time	3	0	3	0	100	0	3	0	30	0	30	0	60	0	60	0
2	Repo Time	4	0	4	0	127	0	4	0	40	0	40	0	80	0	80	0
16	Stop Rules	5	0	5	0	169	0	5	0	50	0	50	0	100	0	100	0
50%	Shrink %	6	0	6	0	200	1	6	9	60	0	60	0	120	2	120	2
1.5	Expand Rules	7	0	7	0	225	0	7	23	70	0	70	1	140	8	140	7
1	8-PI Time	8	0	8	0	254	0	8	32	80	0	80	3	160	8	160	7
200%	Expand %	9	0	9	0	300	0	9	23	90	2	90	10	180	4	180	5
		10	0	10	0	338	0	10	9	100	8	100	18	200	13	200	12
		11	0	11	0	400	44	11	2	110	14	110	22	220	12	220	12
		12	0	12	0	450	0	12	1	120	18	120	19	240	12	240	11
		13	2	13	0	600	0	13	1	130	15	130	8	260	5	260	8
		14	6	14	1	800	55	14	0	140	13	140	7	280	10	280	10
		15	11	15	6	900	0	15	0	150	3	150	6	300	6	300	6
		16	18	16	9	1200	0	16	0	160	9	160	2	320	10	320	10
		17	28	17	17	1600	0	17	0	170	6	170	1	340	1	340	1
		18	15	18	18	More	U	18	0	180	3	180	0	360	2	360	2
		19	11	19	24	More	U	19	0	190	1	190	0	380	1	380	1
		20	6	20	14	More	U	20	0	200	3	200	0	400	0	400	0
		21	3	21	5	More	U	21	0	210	1	210	0	420	0	420	0
		22	0	22	4	More	U	22	0	220	0	220	0	440	3	440	3
		23	0	23	0	More	U	23	0	230	2	230	0	460	0	460	0
		24	0	24	2	More	U	24	0	240	0	240	0	480	0	480	0
		25	0	25	0	More	U	25	0	250	0	250	0	500	2	500	2
		26	0	26	0	More	U	26	0	260	0	260	0	520	1	520	1
		27	0	27	0	More	U	27	0	270	0	270	0	540	0	540	0
		28	0	28	0	More	U	28	0	280	0	280	0	560	0	560	0
		29	0	29	0	More	U	29	0	290	0	290	0	580	0	580	0
		30	0	30	0	More	U	30	0	300	0	300	0	600	0	600	0
		More	U	More	U	More	U	More	U	More	U	More	U	620	1	620	1
														640	0	640	0
														660	0	660	0
														680	0	680	0
														700	0	700	0
														More	1	More	1

Run #	SYSTEM	EVT		Tev		FASZ		RndT		MSDR		A/Avg(MT)		MSR		MSR(C)	
		Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#
30	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
800	Start Area	1	0	1	0	50	0	1	0	10	0	10	0	20	0	20	0
8	Days	2	0	2	0	95	0	2	0	30	0	30	0	40	0	40	0
2	Loc Time	3	0	3	0	100	0	3	0	30	0	30	0	60	0	60	0
2	Repo Time	4	0	4	0	127	0	4	0	40	0	40	0	80	0	80	0
16	Stop Rules	5	0	5	0	169	0	5	1	50	0	50	0	100	0	100	0
25%	Shrink %	6	0	6	0	200	0	6	11	60	0	60	0	120	2	120	2
1.5	Expand Rules	7	0	7	0	225	0	7	24	70	0	70	2	140	6	140	5
1	8-PI Time	8	0	8	0	254	0	8	27	80	3	80	4	160	8	160	8
200%	Expand %	9	0	9	0	300	0	9	21	90	4	90	12	180	7	180	6
		10	0	10	0	338	1	10	10	100	9	100	15	200	11	200	13
		11	1	11	0	400	0	11	2	110	15	110	22	220	12	220	12
		12	3	12	0	450	8	12	0	120	9	120	15	240	9	240	9
		13	2	13	1	600	38	13	0	130	12	130	11	260	7	260	7
		14	13	14	1	800	53	14	0	140	10	140	8	280	8	280	8
		15	20	15	7	900	0	15	0	150	9	150	4	300	4	300	4
		16	19	16	17	1200	0	16	0	160	7	160	2	320	7	320	7
		17	17	17	22	1600	0	17	0	170	11	170	1	340	5	340	5
		18	12	18	24	More	U	18	0	180	2	180	0	360	2	360	2
		19	7	19	17	More	U	19	0	190	4	190	0	380	1	380	1
		20	4	20	9	More	U	20	0	200	1	200	0	400	1	400	1
		21	2	21	3	More	U	21	0	210	0	210	0	420	3	420	2
		22	0	22	1	More	U	22	0	220	0	220	0	440	0	440	1
		23	0	23	0	More	U	23	0	230	1	230	0	460	0	460	0
		24	0	24	0	More	U	24	0	240	0	240	0	480	0	480	0
		25	0	25	0	More	U	25	0	250	2	250	0	500	1	500	1
		26	0	26	0	More	U	26	0	260	0	260	0	520	3	520	3
		27	0	27	0	More	U	27	0	270	0	270	0	540	0	540	0
		28	0	28	0	More	U	28	0	280	0	280	0	560	0	560	0
		29	0	29	0	More	U	29	0	290	0	290	0	580	0	580	0
		30	0	30	0	More	U	30	0	300	0	300	0	600	0	600	0
		More	U	More	U	More	U	More	U	More	U	More	U	620	1	620	1
														640	0	640	0
														660	0	660	0
														680	0	680	0
														700	0	700	0
														More	2	More	2

Table B-3. Simulation Results (cont)

Run #	EYC		Tew		FASz		RndT		RndT(c)		MdsR		AAvg(RT)		AAvg(RT(C))		MSR		MSR(C)	
	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SYSTEM																				
A	1	0	1	0	0	0	1	0	1	0	10	0	10	0	10	0	20	0	20	0
Start Area	8	2	0	3	0	95	0	2	0	2	0	20	0	20	0	40	0	40	0	0
Days	2	3	0	2	0	100	0	3	0	3	0	30	0	30	0	60	0	60	0	0
Loc Time	2	3	0	3	0	127	0	4	0	4	0	40	0	40	0	80	0	80	0	0
Repo Time	4	0	4	0	4	0	4	0	4	0	50	0	50	0	50	0	100	0	100	0
Stop Rules	12	5	0	5	0	169	0	5	1	6	0	60	0	60	0	120	0	120	0	0
Shrink %	50%	6	0	6	0	200	8	6	7	13	60	0	70	1	70	0	140	2	140	1
Expand Rules	7	0	7	0	7	0	225	0	7	20	70	0	80	2	80	0	160	8	160	11
Shrink %	1.5	8	0	8	0	254	0	8	36	9	80	1	90	11	90	0	180	10	180	10
5-41 Time	1	9	0	9	0	300	0	9	21	11	100	11	110	26	110	100	200	14	200	13
6-41 Time	1	10	0	10	0	338	0	10	11	10	110	11	120	17	120	110	220	13	220	13
Expand %	200%	11	0	11	0	400	79	11	1	12	130	6	140	13	140	130	260	10	240	10
		12	0	12	0	450	0	12	1	12	140	4	150	12	150	130	280	7	280	7
		13	0	13	0	600	0	13	1	14	170	8	180	17	180	140	300	4	300	5
		14	0	14	0	800	13	14	0	15	0	160	6	160	150	150	320	7	320	7
		15	0	15	0	900	0	15	0	16	0	170	8	170	170	170	340	4	340	4
		16	3	16	0	1200	0	16	0	18	0	180	2	180	180	180	380	1	380	1
		17	11	17	1	1600	0	17	0	18	0	190	1	190	190	190	380	1	380	1
		18	16	18	6	More	0	18	0	19	0	200	1	200	200	200	400	1	400	1
		19	19	19	8	More	0	19	0	20	0	210	1	210	210	210	420	1	420	1
		20	19	20	20	More	0	20	0	20	0	220	1	220	220	220	440	1	440	2
		21	17	21	17	More	0	21	0	21	0	230	0	230	230	230	460	0	460	0
		22	9	22	15	More	0	22	0	22	0	240	0	240	240	240	480	2	480	2
		23	2	23	16	More	0	23	0	23	0	250	1	250	250	250	500	0	500	2
		24	1	24	10	More	0	24	0	24	0	260	0	260	260	260	520	1	520	0
		25	0	25	3	More	0	25	0	25	0	270	0	270	270	270	540	0	540	0
		26	0	26	2	More	0	26	0	27	0	280	0	280	280	280	560	0	560	0
		27	0	27	0	More	0	27	0	27	0	290	0	290	290	290	580	0	580	0
		28	0	28	0	More	0	28	0	28	0	300	0	300	300	300	600	1	600	1
		29	0	29	0	More	0	29	0	29	0	310	0	310	310	310	620	0	620	0
		30	0	30	0	More	0	30	0	30	0	320	0	320	320	320	640	0	640	0
		More	0	More	0	More	0	More	0	More	0	330	0	330	330	330	660	0	660	0
												340	0	340	340	340	680	0	680	0
												350	0	350	350	350	700	0	700	0
												More	0	More	0	More	1	More	1	More

Run #	SYSTEM	A	EVT		Tev		FASz		RndT		RndT(C)		MdsR		A/Avg(MT)		A/Avg(TC)		MSR		MSR(C)	
			#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin
32	800	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Start Area	Days	6	1	0	1	0	50	0	1	0	1	0	10	0	10	0	10	0	20	0	20	
Loc Time	2	2	0	2	0	2	95	0	2	0	2	0	20	0	20	0	40	0	40	0	40	
Rept Rules	2	3	0	3	0	100	0	3	0	3	0	30	0	30	0	30	0	60	0	60	0	
Stop Time	4	4	0	4	0	127	0	4	0	4	0	40	0	40	0	40	0	80	0	80	0	
Shrink %	25%	12	5	0	5	0	169	0	5	1	5	1	50	0	50	0	50	0	100	0	100	
Expand Rules	1	7	0	6	0	200	0	6	7	6	21	60	0	60	0	60	0	70	0	120	1	
6-Pt Time	1.5	8	0	8	0	225	0	7	27	7	34	70	1	70	1	70	1	80	1	160	6	
5-Pt Time	200%	1	9	0	9	0	300	0	8	29	8	32	80	2	90	8	90	8	180	5	180	
Expand %		10	0	10	0	338	4	10	7	10	3	100	7	100	19	100	19	100	8	200	16	
		11	0	11	0	400	0	11	6	11	110	16	110	16	110	20	110	20	220	9	220	
		12	0	12	0	450	45	12	1	12	0	120	10	120	19	120	19	120	26	240	8	
		13	2	13	0	600	40	13	0	13	0	130	16	130	16	130	16	130	26	260	11	
		14	3	14	0	900	11	14	0	14	0	140	13	140	3	140	3	140	12	280	9	
		15	10	15	0	900	0	15	0	15	0	150	7	150	3	150	3	150	12	300	8	
		16	20	16	2	1200	0	16	0	16	0	160	9	160	1	160	1	160	320	300	8	
		17	21	17	6	1600	0	17	0	17	0	170	6	170	1	170	1	170	340	340	1	
		18	1/	18	1/	More	U	18	U	18	U	180	3	180	1	180	1	180	U	340	2	
		19	17	19	23	More	U	19	0	19	0	190	2	190	0	190	0	190	390	390	3	
		20	8	20	17	More	U	20	0	20	0	200	2	200	1	200	1	200	400	400	2	
		21	1	21	20	More	U	21	U	21	U	210	0	210	U	210	U	210	420	420	1	
		22	1	22	10	More	U	22	0	22	0	220	1	220	0	220	0	220	440	440	1	
		23	0	23	4	More	U	23	0	23	0	230	0	230	0	230	0	230	460	460	1	
		24	0	24	1	More	U	24	0	24	1	240	2	240	0	240	0	240	480	480	1	
		25	0	25	0	More	U	25	0	25	0	250	1	250	0	250	0	250	500	500	2	
		26	0	26	0	More	U	26	0	26	0	260	0	260	0	260	0	260	520	520	0	
		27	0	27	0	More	U	27	0	27	0	270	0	270	0	270	0	270	540	540	0	
		28	0	28	0	More	U	28	0	28	0	280	0	280	0	280	0	280	560	560	0	
		29	0	29	0	More	U	29	0	29	0	290	0	290	0	290	0	290	580	580	0	
		30	0	30	0	More	U	30	0	30	0	300	0	300	0	300	0	300	600	600	1	
		More	U	More	U	More	U	More	U	More	U	310	U	310	U	310	U	310	620	620	1	
												320	0	320	0	320	0	320	640	640	0	
												330	0	330	0	330	0	330	660	660	0	
												340	0	340	0	340	0	340	680	680	0	
												350	0	350	0	350	0	350	700	700	1	
												More	U	More	U	More	U	More	1	More	1	

Table B-3. Simulation Results (cont)

Run #	SYSTEM	Start Area	Days	Loc Time	Rep Time	Stop Rules	Shrink %	Expand Rules	8-PI Time	Expand %	EvTC	Tev	FASZ	RndT	RndT(C)	MSR	A/Avg(NT)	MSR	MSR(C)	#
33	A	800	8	4	2	24	50%	1.5	1	200%	Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin
											0	0	0	0	0	0	0	0	0	0
											1	0	0	0	0	0	0	0	0	0
											2	0	0	0	0	0	0	0	0	0
											3	0	0	0	0	0	0	0	0	0
											4	0	0	0	0	0	0	0	0	0
											5	0	0	0	0	0	0	0	0	0
											6	0	0	0	0	0	0	0	0	0
											7	0	0	0	0	0	0	0	0	0
											8	0	0	0	0	0	0	0	0	0
											9	0	0	0	0	0	0	0	0	0
											10	0	0	0	0	0	0	0	0	0
											11	0	0	0	0	0	0	0	0	0
											12	0	0	0	0	0	0	0	0	0
											13	0	0	0	0	0	0	0	0	0
											14	0	0	0	0	0	0	0	0	0
											15	0	0	0	0	0	0	0	0	0
											16	0	0	0	0	0	0	0	0	0
											17	0	0	0	0	0	0	0	0	0
											18	0	0	0	0	0	0	0	0	0
											19	0	0	0	0	0	0	0	0	0
											20	0	0	0	0	0	0	0	0	0
											21	0	0	0	0	0	0	0	0	0
											22	0	0	0	0	0	0	0	0	0
											23	0	0	0	0	0	0	0	0	0
											24	0	0	0	0	0	0	0	0	0
											25	0	0	0	0	0	0	0	0	0
											26	0	0	0	0	0	0	0	0	0
											27	0	0	0	0	0	0	0	0	0
											28	0	0	0	0	0	0	0	0	0
											29	0	0	0	0	0	0	0	0	0
											30	0	0	0	0	0	0	0	0	0
											More	More	More	More	More	More	More	More	More	More

Table B-3. Simulation Results (cont)

SYSTEM	Run #	EUTC		Tev		FASZ		RadT		RadT(C)		ASB&K		ASB&K(%)		ASB&K(%)		ASB&K(%)	
		#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin
35	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
800	B	1	0	1	0	50	0	1	0	1	0	10	0	10	0	10	0	20	0
8	C	2	0	2	0	95	0	2	0	2	0	20	0	20	0	40	0	40	0
4	D	3	0	3	0	100	0	3	0	3	0	30	0	30	0	60	0	60	0
2	E	4	0	4	0	127	0	4	0	4	0	40	0	40	0	80	0	80	0
20	F	5	0	5	0	169	0	5	2	5	2	50	0	50	0	100	0	100	0
50%	G	6	0	6	0	225	0	6	13	6	15	60	0	60	1	60	1	120	1
1.5	H	7	0	7	0	225	0	7	22	7	23	70	2	70	1	70	0	140	5
1	I	8	0	8	0	254	0	8	25	8	28	80	3	80	4	80	4	160	11
4	J	9	0	9	0	300	0	9	23	9	20	90	3	90	12	90	13	180	13
200%	K	10	3	10	0	336	0	10	9	10	6	100	6	100	20	100	8	200	8
	L	11	8	11	3	400	9	11	3	11	3	110	10	110	20	110	22	220	11
	M	12	8	12	8	450	0	12	1	12	1	120	15	120	10	120	24	240	8
	N	13	28	13	18	600	0	13	1	13	0	130	14	130	12	130	11	260	12
	O	14	20	14	33	800	91	14	1	14	0	140	11	140	11	140	5	280	4
	P	15	19	15	17	900	0	15	0	15	0	150	8	150	5	150	5	300	4
	Q	16	10	16	13	1200	0	16	0	16	0	160	9	160	2	160	3	320	4
	R	17	4	17	8	1600	0	17	0	17	0	170	6	170	2	170	2	340	2
	S	18	0	18	0	More	0	18	0	18	0	180	4	180	0	180	4	360	2
	T	19	0	19	0	More	0	19	0	19	0	190	4	190	0	190	4	380	2
	U	20	0	20	0	More	0	20	0	20	0	200	2	200	0	200	2	400	1
	V	21	0	21	0	More	0	21	0	21	0	210	1	210	0	210	1	420	1
	W	22	0	22	0	More	0	22	0	22	0	220	0	220	0	220	0	440	0
	X	23	0	23	0	More	0	23	0	23	0	230	0	230	0	230	0	460	2
	Y	24	0	24	0	More	0	24	0	24	0	240	0	240	0	240	0	480	0
	Z	25	0	25	0	More	0	25	0	25	0	250	1	250	0	250	1	500	0
	AA	26	0	26	0	More	0	26	0	26	0	260	0	260	0	260	0	520	0
	AB	27	0	27	0	More	0	27	0	27	0	270	0	270	0	270	0	540	0
	AC	28	0	28	0	More	0	28	0	28	0	280	0	280	0	280	0	560	0
	AD	29	0	29	0	More	0	29	0	29	0	290	0	290	0	290	0	580	1
	AE	30	0	30	0	More	0	30	0	30	0	300	0	300	0	300	1	600	1
More	AF	More	0	More	0	More	0	More	0	More	0	310	U	310	U	310	U	620	U
	AG	More	0	More	0	More	0	More	0	More	0	320	0	320	0	320	0	640	0
	AH	More	0	More	0	More	0	More	0	More	0	330	0	330	0	330	0	660	0
	AI	More	0	More	0	More	0	More	0	More	0	340	0	340	0	340	0	680	0
	AJ	More	0	More	0	More	0	More	0	More	0	350	0	350	0	350	1	700	1
	AK	More	0	More	0	More	0	More	0	More	0	More	U	More	U	More	U	More	U

Run #	ExpFC		Tev		FASZ		RndT		RndT(C)		MCSR		A/Avg(NT)		A/Avg(NT(C))		MSR		MSR(C)	
	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin
36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SYSTEM	1	1	0	1	0	50	0	1	0	1	0	10	10	10	10	10	20	20	20	20
Start Area	2	3	0	2	0	95	0	2	0	2	0	20	20	20	20	20	40	40	40	40
Days	4	4	0	3	0	100	0	3	0	3	0	30	30	30	30	30	60	60	60	60
Loc Time	2	3	0	3	0	100	0	3	0	3	0	40	40	40	40	40	80	80	80	80
Repo Time	4	4	0	4	0	127	0	4	0	4	0	50	50	50	50	50	100	100	100	100
Stop Rules	20	5	0	5	0	169	0	5	1	5	1	14	14	14	14	14	120	120	120	120
Stop Time	25%	6	0	6	0	200	0	6	11	6	24	24	24	24	24	24	160	160	160	160
Shrink %	1.5	7	0	7	0	225	0	7	24	7	31	31	31	31	31	31	180	180	180	180
Expand Rules	1	8	0	8	0	254	0	8	30	8	17	17	17	17	17	17	160	160	160	160
5-P4 Time	200%	9	0	9	0	300	0	9	17	9	30	30	30	30	30	30	180	180	180	180
Expand %	1	10	0	10	0	338	0	10	11	10	8	100	100	100	100	100	160	160	160	160
		11	9	11	1	450	0	11	3	11	17	110	110	110	110	110	220	220	220	220
		12	14	12	11	450	1	12	2	12	18	120	120	120	120	120	240	240	240	240
		13	29	13	19	600	8	13	1	13	10	130	130	130	130	130	260	260	260	260
		14	18	14	28	900	91	14	0	14	6	140	140	140	140	140	280	280	280	280
		15	19	15	28	900	0	15	0	15	9	150	150	150	150	150	300	300	300	300
		16	7	16	8	1200	0	16	0	16	0	160	160	160	160	160	320	320	320	320
		17	3	17	4	1500	0	17	0	17	8	170	170	170	170	170	340	340	340	340
		18	1	18	1	None	0	18	0	18	18	180	180	180	180	180	360	360	360	360
		19	0	19	0	None	0	19	0	19	0	190	190	190	190	190	380	380	380	380
		20	0	20	0	None	0	20	0	20	0	200	200	200	200	200	400	400	400	400
		21	0	21	0	None	0	21	0	21	0	210	210	210	210	210	420	420	420	420
		22	0	22	0	None	0	22	0	22	0	220	220	220	220	220	440	440	440	440
		23	0	23	0	None	0	23	0	23	0	230	230	230	230	230	460	460	460	460
		24	0	24	0	None	0	24	0	24	0	240	240	240	240	240	480	480	480	480
		25	0	25	0	None	0	25	0	25	0	250	250	250	250	250	500	500	500	500
		26	0	26	0	None	0	26	0	26	0	260	260	260	260	260	520	520	520	520
		27	0	27	0	None	0	27	0	27	0	270	270	270	270	270	540	540	540	540
		28	0	28	0	None	0	28	0	28	0	280	280	280	280	280	560	560	560	560
		29	0	29	0	None	0	29	0	29	0	290	290	290	290	290	580	580	580	580
		30	0	30	0	None	0	30	0	30	0	300	300	300	300	300	600	600	600	600
		More	0	More	0	None	0	More	0	More	0	310	310	310	310	310	620	620	620	620
												320	320	320	320	320	640	640	640	640
												330	330	330	330	330	660	660	660	660
												340	340	340	340	340	680	680	680	680
												350	350	350	350	350	700	700	700	700
												More	More	More	More	More	More	More	More	More

Table B-3. Simulation Results (cont)

Run #	SYSTEM	EvtC		Tev		FASZ		RndT		RndT(C)		MidSR		A/Avg(N/T)		MSR		A/Avg(N/T(C))		MSR		MSR(C)	
		Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#
37	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
800	Start Area	1	0	1	0	50	0	1	0	1	0	10	0	10	0	20	0	20	0	20	0	20	0
8	Days	2	0	2	0	95	0	2	0	2	0	20	0	20	0	40	0	40	0	40	0	40	0
4	Loc Time	3	0	3	0	100	0	3	0	3	0	30	0	30	0	60	0	60	0	60	0	60	0
2	Rego Time	4	0	4	0	127	0	4	0	4	0	40	0	40	0	80	0	80	0	80	0	80	0
16	Stop Rules	5	0	5	0	169	0	5	2	5	3	50	0	50	0	100	0	100	0	100	0	100	0
50%	Shrink %	6	0	6	0	200	1	6	12	6	13	60	0	60	0	120	4	120	4	120	4	120	4
1	Stop Time	7	0	7	0	225	0	7	20	7	24	70	0	70	1	140	4	140	4	140	4	140	4
1.5	Expand Rules	8	0	8	0	254	0	8	28	8	38	80	2	80	6	160	5	160	5	160	5	160	5
5-PT Time	6-PT Time	9	0	9	0	300	0	9	25	9	33	90	3	90	7	180	10	180	10	180	10	180	10
200%	Expand %	10	0	10	0	338	0	10	6	10	6	100	4	100	24	240	9	240	9	240	9	240	9
		11	2	11	0	400	35	11	5	11	1	110	17	110	22	220	20	220	20	220	20	220	20
		12	13	12	1	450	0	12	1	12	0	120	15	120	12	240	9	240	9	240	9	240	9
		13	27	13	12	600	0	13	1	13	0	130	18	130	13	260	5	260	5	260	5	260	5
		14	22	14	22	800	64	14	0	14	0	140	9	140	5	280	6	280	6	280	6	280	6
		15	19	15	23	900	0	15	0	15	0	150	6	150	2	300	9	300	9	300	9	300	9
		16	10	16	25	1200	0	16	0	16	0	160	7	160	6	320	3	320	3	320	3	320	3
		17	7	17	12	1600	0	17	0	17	0	170	7	170	2	340	5	340	5	340	5	340	5
		18	0	18	3	More	U	18	0	18	0	180	4	180	0	360	2	360	2	360	2	360	2
		19	0	19	2	More	U	19	0	19	0	190	1	190	0	380	1	380	1	380	1	380	1
		20	0	20	0	20	0	20	0	20	0	200	2	200	0	400	1	400	1	400	1	400	1
		21	0	21	0	210	U	21	0	210	U	210	0	210	0	420	0	420	0	420	0	420	0
		22	0	22	0	220	U	22	0	220	U	220	0	220	0	440	0	440	0	440	0	440	0
		23	0	23	0	230	0	23	0	230	0	230	0	230	0	460	2	460	2	460	2	460	2
		24	0	24	0	240	0	24	0	240	0	240	1	240	0	480	0	480	0	480	0	480	0
		25	0	25	0	250	0	25	0	250	0	250	0	250	0	500	0	500	0	500	0	500	0
		26	0	26	0	260	0	26	0	260	0	260	1	260	0	520	0	520	0	520	0	520	0
		27	0	27	0	270	0	27	0	270	0	270	0	270	0	540	1	540	1	540	1	540	1
		28	0	28	0	280	0	28	0	280	0	280	0	280	0	560	2	560	2	560	2	560	2
		29	0	29	0	290	0	29	0	290	0	290	0	290	0	580	0	580	0	580	0	580	0
		30	0	30	0	300	U	30	0	300	U	300	0	300	0	600	1	600	1	600	1	600	1
		More	U	More	U	More	U	More	U	More	U	More	U	More	U	More	U	More	U	More	U	More	U

38	Run #	SYSTEM	EUTC		Tev		FASZ		RndT		RndT(C)		MSR		A/Avg(N/T)		MSR		A/Avg(N/T(C))		MSR(C)	
			Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#
A	800	Start Area	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
B	8	Days	1	0	1	0	50	0	1	0	1	0	10	0	10	0	20	0	20	0	20	0
C	4	Loc Time	2	0	2	0	95	0	2	0	2	0	20	0	20	0	40	0	40	0	40	0
D	2	Rego Time	3	0	3	0	100	0	3	0	3	0	30	0	30	0	60	0	60	0	60	0
E	16	Stop Rules	4	0	4	0	127	0	4	1	4	1	40	0	40	0	80	0	80	0	80	0
F	25%	Shrink %	5	0	5	0	169	0	5	1	5	2	50	0	50	0	100	0	100	0	100	0
G	1	Expand Rules	6	0	6	0	200	0	6	13	6	15	60	0	60	0	120	0	120	0	120	0
H	1.5	6-PT Time	7	0	7	0	225	0	7	13	7	19	70	1	70	3	140	7	140	6	140	6
I	1	5-PT Time	8	0	8	0	254	0	8	39	8	42	80	3	80	8	160	7	160	7	160	7
J	200%	Expand %	9	0	9	0	300	0	9	20	9	15	90	4	90	6	180	10	180	10	180	10
K			10	0	10	0	338	0	10	7	10	5	100	7	100	19	200	14	200	14	200	14
L			11	6	11	0	400	0	11	1	11	0	110	17	110	31	220	11	220	11	220	11
M			12	13	12	1	450	4	12	4	12	1	120	15	120	12	240	10	240	9	240	9
N			13	31	13	9	600	32	13	1	13	0	130	14	130	8	260	8	260	9	260	9
O			14	27	14	34	800	64	14	0	14	0	140	12	140	12	280	12	280	11	280	11
P			15	12	15	34	900	0	15	0	15	0	150	7	150	4	300	1	300	4	300	4
Q			16	7	16	13	1200	0	16	0	16	0	160	10	160	2	320	2	320	2	320	2
R			17	3	17	6	1600	0	17	0	17	0	170	2	170	1	340	2	340	2	340	2
S			18	0	18	0	More	U	18	0	18	0	180	6	180	4	360	2	360	2	360	2
T			19	1	19	1	More	U	19	0	19	0	190	0	190	0	380	3	380	3	380	3
U			20	0	20	0	20	0	20	0	20	0	200	2	200	0	400	2	400	2	400	2
V			21	0	21	0	210	U	21	0	21	0	210	0	210	0	420	1	420	1	420	1
W			22	0	22	0	220	U	22	0	22	0	220	0	220	0	440	1	440	1	440	1
X			23	0	23	0	230	0	23	0	23	0	230	0	230	1	460	1	460	1	460	1
Y			24	0	24	0	240	0	24	0	24	0	240	0	240	0	480	0	480	0	480	0
Z			25	0	25	0	250	0	25	0	25	0	250	0	250	0	500	0	500	0	500	0
AA			26	0	26	0	260	0	26	0	26	0	260	1	260	0	520	0	520	0	520	0
AB			27	0	27	0	270	0	27	0	27	0	270	0	270	0	540	1	540	1	540	1
AC			28	0	28	0	280	0	28	0	28	0	280	1	280	0	560	1	560	1	560	1
AD			29	0	29	0	290	0	29	0	29	0	290	0	290	0	580	1	580	1	580	1
AE			30	0	30	0	300	U	30	0	30	0	300	0	300	0	600	1	600	1	600	1
AF			More	U	More	U	More	U	More	U	More	U	More	U	More	U	620	0	620	0	640	0
AG																	640	0	640	0	640	0
AH																	660	0	660	0	660	0
AI																	680	0	680	0	680	0
AJ																	700	1	700	1	700	1
AK																	More	More	More	More	More	More

Table B-3. Simulation Results (cont)

Run #	SYSTEM	Start Area	Days	Loc Time	Rego Time	Stop Rules	Shrink %	Expand Rules	Expand %	Ex/TC	Tev	FASz	RedT	RedT(C)	MSR	A/Avg(NT)	A/Avg(NT(C))	MSR	MSR(C)
39	A	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40	B	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
41	C	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
42	D	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
43	E	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44	F	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
45	G	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46	H	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
47	I	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48	J	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
49	K	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50	L	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
51	M	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
52	N	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
53	O	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
54	P	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55	Q	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
56	R	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
57	S	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
58	T	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
59	U	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60	V	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
61	W	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
62	X	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
63	Y	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
64	Z	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
65	AA	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
66	AB	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
67	AC	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
68	AD	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
69	AE	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
70	AF	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
71	AG	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
72	AH	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
73	AI	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
74	AJ	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
75	AK	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
76	AL	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
77	AM	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78	AN	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
79	AO	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
80	AP	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
81	AQ	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
82	AR	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
83	AS	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
84	AT	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
85	AU	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
86	AV	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
87	AW	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
88	AX	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
89	AY	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90	AZ	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
91	BA	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
92	BB	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
93	BC	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
94	BD	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
95	BE	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	BF	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	BG	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	BH	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
99	BI	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100	BJ	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table B-3. Simulation Results (cont)

Run #	SYSTEM	Start Area	Days	Loc Time	Repo Time	Stop Rules	Stop Time	Shrink %	Expand Rules	6-Pt Time	5-Pt Time	Expand %	EvTC	#	Tev	#	FASz	#	RndT	#	Rnd(C)	#	MSR	#	A/Avg(NT)	#	A/Avg(NTC)	#	MSR	#	MSRC	#
													Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin
41	800	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
8	1	0	1	0	50	0	1	0	1	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
8	2	0	2	0	95	0	2	0	2	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2	3	0	3	0	100	0	3	0	3	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
4	4	0	4	0	127	0	4	0	4	0	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
24	5	0	5	0	169	0	5	3	5	0	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
50%	6	0	6	0	200	0	6	17	6	0	60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1	7	0	7	0	225	0	7	22	7	0	70	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1.5	8	6	8	0	253	0	8	23	8	0	80	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
200%	1	9	17	9	300	0	9	15	9	15	90	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	10	22	10	23	337	0	10	6	10	6	100	10	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	11	35	11	39	400	1	11	10	11	10	110	11	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	12	19	12	20	450	0	12	3	12	3	120	10	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	13	1	13	1	600	0	13	1	13	0	140	11	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	14	0	14	0	800	99	14	0	14	0	150	6	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	15	0	15	0	900	0	15	0	15	0	160	11	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	16	0	16	0	1200	0	16	0	16	0	170	9	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	17	0	17	0	1600	0	17	0	17	0	180	3	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	18	0	18	0	1800	0	18	0	18	0	190	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	19	0	19	0	1900	0	19	0	19	0	200	2	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	20	0	20	0	2000	0	20	0	20	0	210	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	21	0	21	0	2100	0	21	0	21	0	220	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	22	0	22	0	2200	0	22	0	22	0	230	1	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	23	0	23	0	2300	0	23	0	23	0	240	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	24	0	24	0	2400	0	24	0	24	0	250	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	25	0	25	0	2500	0	25	0	25	0	260	1	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	26	0	26	0	2600	0	26	0	26	0	270	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	27	0	27	0	2700	0	27	0	27	0	280	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	28	0	28	0	2800	0	28	0	28	0	290	1	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	29	0	29	0	2900	0	29	0	29	0	300	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	30	0	30	0	3000	0	30	0	30	0	310	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
None	U	More	U	More	U	More	U	More	U	More	U	More	U	More	U	More	U	More	U	More	U	More	U	More	U	More	U	More	U	More	U	

Run #	SYSTEM	Start Area	Days	Loc Time	Repo Time	Stop Rules	Shrink %	Expand Rules	6 Pt Time	5 Pt Time	Expand %	EvTC		Tev		FASz		RndT		RndTC		MSR		A/Avg(NT)		MSR		MSRC	
												#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin
42	A	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
8	8	1	0	1	0	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
8	8	2	0	2	0	95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2	2	3	0	3	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
24	24	4	0	4	0	127	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
25%	25%	5	0	5	0	169	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1.5	1.5	6	0	6	0	200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1	1	7	0	7	0	225	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
200%	200%	8	6	8	0	253	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		9	17	9	17	300	0	9	15	9	6	100	10	10	10	6	100	10	10	10	11	110	100	100	14	200	9	200	9
		10	22	10	23	337	0	10	6	10	10	10	10	11	10	10	10	10	11	10	110	110	110	110	11	220	13	220	13
		11	35	11	39	400	0	11	12	10	12	120	10	12	10	12	120	10	120	120	120	120	120	120	120	120	13	240	8
		12	19	12	20	450	0	12	3	12	3	120	10	13	0	130	100	130	130	130	130	130	130	130	130	130	10	260	10
		13	1	13	1	600	99	14	0	14	0	140	9	14	0	140	9	140	140	140	140	140	140	140	140	7	280	4	
		14	0	14	0	800	0	15	0	15	0	150	6	150	6	150	6	150	150	150	150	150	150	150	150	6	300	6	
		15	0	15	0	900	0	16	0	16	0	160	11	160	11	160	11	160	160	160	160	160	160	160	160	4	320	3	
		16	0	16	0	1200	0	17	0	17	0	170	9	170	9	170	9	170	170	170	170	170	170	170	170	2	340	3	
		17	0	17	0	1600	0	18	0	18	0	180	3	180	3	180	3	180	180	180	180	180	180	180	180	0	360	0	
		18	0	18	0	1800	0	19	0	19	0	190	2	190	2	190	2	190	190	190	190	190	190	190	190	0	380	4	
		19	0	19	0	1900	0	20	0	20	0	200	4	200	4	200	4	200	200	200	200	200	200	200	200	1	400	2	
		20	0	20	0	2000	0	21	0	21	0	210	2	210	2	210	2	210	210	210	210	210	210	210	210	1	420	1	
		21	0	21	0	2100	0	22	0	22	0	220	0	220	0	220	0	220	220	220	220	220	220	220	220	0	440	1	
		22	0	22	0	2200	0	23	0	23	0	230	1	230	1	230	1	230	230	230	230	230	230	230	230	0	460	0	
		23	0	23	0	2300	0	24	0	24	0	240	0	240	0	240	0	240	240	240	240	240	240	240	240	0	480	0	
		24	0	24	0	2400	0	25	0	25	0	250	0	250	0	250	0	250	250	250	250	250	250	250	250	0	500	1	
		25	0	25	0	2500	0	26	0	26	0	260	1	260	1	260	1	260	260	260	260	260	260	260	260	0	520	0	
		26	0	26	0	2600	0	27	0	27	0	270	0	270	0	270	0	270	270	270	270	270	270	270	270	0	540	0	
		27	0	27	0	2700	0	28	0	28	0	280	0	280	0	280	0	280	280	280	280	280	280	280	280	0	560	0	
		28	0	28	0	2800	0	29	0	29	0	290	1	290	1	290	1	290	290	290	290	290	290	290	290	1	580	1	
		29	0	29	0	2900	0	30	0	30	0	300	0	300	0	300	0	300	300	300	300	300	300	300	300	0	600	0	
		30	0	30	0	3000	0	31	0	31	0	310	0	310	0	310	0	310	310	310	310	310	310	310	310	0	620	0	
		More	U	More	U	More	U	More	U	More	U	More	U	More	U	More	U	More	More	More	More	More	More	More	More	0	640	1	
																										0	660	0	
																										0	680	0	
																										0	700	0	
																										0	720	0	
																										0	740	0	
																										0	760	0	
																										0	780	0	
																										0	800	0	
																										0	820	0	
																										0	840	1	
																										0	860	0	
																										0	880	0	
																										0	900	0	
																										0	920	0	
																										0	940	0	
																										0	960	0	
																										0	980	0	
																										0	1000	0	
																										0	1020	0	
																										0	1040	0	
																										0	1060	0	
																										0	1080	0	
																										0	1100	0	
																										0	1120	0	
																										0	1140	0	
																										0	1160	0	
																										0	1180	0	
																										0	1200	0	
																										0	1220	0	
																										0	1240	0	
																										0	1260	0	
																										0	1280	0	
																										0	1300	0	
																										0	1320	0	
																										0	1340	0	
																										0	1360	0	
																										0	1380	0	
																										0	1400	0	
																										0	1420	0	
																										0	1440	0	
																										0	1460	0	
																										0	1480	0	
																										0	1500	1	
																										0	1520	0	

Table B-3. Simulation Results (cont)

Run #	SYSTEM	43	EVT		Tev		FASz		RsdT		RsdT(C)		Midser		AAvg(WT)		AAvg(NTC)		MSR		MSR(C)	
			#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin
A	806	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
B	8	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	
C	2	0	0	2	0	0	0	0	2	0	2	0	0	0	0	0	0	0	0	0	0	
D	3	0	0	3	0	0	0	0	3	0	3	0	0	0	0	0	0	0	0	0	0	
E	4	0	0	4	0	0	0	0	4	1	4	1	0	0	0	0	0	0	0	0	0	
F	5	0	0	5	0	0	0	0	5	3	5	3	0	0	0	0	0	0	0	0	0	
G	6	0	0	6	0	0	0	0	6	15	6	18	60	0	0	0	0	0	0	0	0	
H	7	1	7	0	225	0	7	24	7	23	7	23	70	2	70	3	70	7	160	4	160	
I	8	5	8	1	253	0	8	23	8	16	90	6	100	6	90	11	80	7	160	6	160	
J	9	15	9	6	300	0	9	14	9	10	6	110	10	110	10	110	12	100	12	200	12	
K	10	28	10	25	337	0	10	9	10	6	110	10	120	10	120	11	120	10	220	14	220	
L	11	34	11	45	400	7	11	6	11	6	110	10	130	10	130	14	130	14	260	8	260	
M	12	18	12	22	450	0	12	1	12	1	120	10	140	14	140	15	140	15	280	9	280	
N	13	0	13	0	600	0	13	3	13	14	0	160	7	160	7	160	4	160	4	320	2	320
O	14	1	14	1	800	93	14	1	14	0	160	7	170	7	170	2	170	2	340	2	340	
P	15	0	15	0	900	0	15	0	15	0	160	7	180	4	180	1	180	1	360	1	360	
Q	16	0	16	0	1200	0	16	0	16	0	170	7	190	4	190	0	190	0	380	4	380	
R	17	0	17	0	1600	0	17	0	17	0	180	4	200	5	200	0	200	0	400	1	400	
S	18	0	18	0	More	0	18	0	18	0	190	4	210	1	210	0	210	0	420	1	420	
T	19	0	19	0	More	0	19	0	19	0	200	5	220	2	220	0	220	0	440	1	440	
U	20	0	20	0	More	0	20	0	20	0	210	1	230	1	230	0	230	0	460	0	460	
V	21	0	21	0	More	0	21	0	21	0	220	2	240	0	240	0	240	0	480	0	480	
W	22	0	22	0	More	0	22	0	22	0	230	1	250	0	250	0	250	0	500	2	500	
X	23	0	23	0	More	0	23	0	23	0	240	0	260	0	260	0	260	0	520	0	520	
Y	24	0	24	0	More	0	24	0	24	0	250	0	280	0	280	0	280	0	540	0	540	
Z	25	0	25	0	More	0	25	0	25	0	260	0	290	1	290	0	290	0	560	0	560	
AA	26	0	26	0	More	0	26	0	26	0	270	0	300	0	300	0	300	0	580	0	580	
AB	27	0	27	0	More	0	27	0	27	0	280	0	310	0	310	0	310	0	600	0	600	
AC	28	0	28	0	More	0	28	0	28	0	290	1	320	0	320	0	320	0	620	0	620	
AD	29	0	29	0	More	0	29	0	29	0	300	0	330	0	330	0	330	0	640	1	640	
AE	30	0	30	0	More	0	30	0	30	0	310	0	340	0	340	0	340	0	660	0	660	
AF	More	More	More	More	More	More	More	More	More	More	More	More	More	More	More	More	More	More	More	More	More	

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Run #	SYSTEM	EXTC	Tow		FASz		RndT		Rnd(C)		MdsR		A/Avg(NT)		A/Avg(NT(C))		MSR		MSR(C)	
			#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin
44																				
800	800	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	8	1	0	1	0	50	1	1	1	0	10	10	10	10	10	20	20	20	20	20
8	8	2	0	2	0	95	0	2	2	0	20	20	20	20	20	40	40	40	40	40
2	2	3	0	3	0	100	0	3	0	30	30	30	30	30	60	60	60	60	60	60
20	20	4	0	4	0	127	0	4	1	40	40	40	40	40	80	80	80	80	80	80
25%	25%	5	0	5	0	169	0	5	2	5	2	50	50	50	100	100	100	100	100	100
1	1	6	0	6	0	200	0	6	16	6	17	60	60	60	120	120	120	120	120	120
1.5	1.5	7	1	7	0	225	0	7	28	7	30	70	70	70	140	140	140	140	140	140
200%	200%	8	3	8	0	253	0	8	17	8	18	80	80	80	160	160	160	160	160	160
		9	18	9	6	300	0	9	14	9	15	90	90	90	180	180	180	180	180	180
		10	35	10	30	337	0	10	14	10	15	100	100	100	14	100	112	100	112	100
		11	26	11	42	400	0	11	4	11	3	110	110	110	10	120	112	100	120	112
		12	15	12	20	450	0	12	2	12	0	120	120	120	16	120	112	100	120	112
		13	1	13	1	600	5	13	1	13	0	130	130	130	17	130	112	100	120	112
		14	1	14	1	800	95	14	1	14	1	140	140	140	9	140	112	100	120	112
		15	0	15	0	900	0	15	0	15	0	150	150	150	7	150	112	100	120	112
		16	0	16	0	1200	0	16	0	16	0	160	160	160	3	160	112	100	120	112
		17	0	17	0	1600	0	17	0	17	0	170	170	170	4	170	112	100	120	112
		18	0	18	0	More	U	18	0	18	0	180	180	180	5	180	112	100	120	112
		19	0	19	0	More	U	19	0	19	0	190	190	190	1	190	112	100	120	112
		20	0	20	0	More	U	20	0	20	0	200	200	200	3	200	112	100	120	112
		21	0	21	0	More	U	21	0	21	0	210	210	210	U	210	112	100	120	112
		22	0	22	0	More	U	22	0	22	0	220	220	220	1	220	112	100	120	112
		23	0	23	0	More	U	23	0	23	0	230	230	230	0	230	112	100	120	112
		24	0	24	0	More	U	24	0	24	0	240	240	240	0	240	112	100	120	112
		25	0	25	0	More	U	25	0	25	0	250	250	250	1	250	112	100	120	112
		26	0	26	0	More	U	26	0	26	0	260	260	260	0	260	112	100	120	112
		27	0	27	0	More	U	27	0	27	0	270	270	270	1	270	112	100	120	112
		28	0	28	0	More	U	28	0	28	0	280	280	280	0	280	112	100	120	112
		29	0	29	0	More	U	29	0	29	0	290	290	290	0	290	112	100	120	112
		30	0	30	0	More	U	30	0	30	0	300	300	300	0	300	112	100	120	112
		More	U	More	U	More	U	More	U	More	U	310	310	310	U	310	620	620	620	620
												320	320	320	0	320	640	640	640	640
												330	330	330	0	330	660	660	660	660
												340	340	340	0	340	680	680	680	680
												350	350	350	0	350	700	700	700	700
												More	More	More	U	More	3	3	3	3

Table B-3. Simulation Results (cont)

Run #	45	EvTC	Tev	FASZ	RndT	RndT(C)	MSR	A/Avg(MT)	MSR	MSR(C)	#
SYSTEM	800	Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin
Start Area	0	0	0	0	0	0	0	0	0	0	0
Days	1	0	1	0	1	0	0	0	0	0	0
Loc Time	2	0	2	0	2	0	0	0	0	0	0
Stop Rules	3	0	3	0	3	0	0	0	0	0	0
Shrink %	4	0	4	0	4	0	0	0	0	0	0
Expand Rules	5	0	5	0	5	0	0	0	0	0	0
6-PI Time	6	0	6	0	6	0	0	0	0	0	0
8-PI Time	7	0	7	0	7	0	0	0	0	0	0
Expand %	8	0	8	0	8	0	0	0	0	0	0
1	9	11	9	0	9	19	9	15	90	3	90
200%	10	39	10	16	337	0	10	7	100	7	100
	11	29	11	36	400	19	11	4	110	12	110
	12	18	12	41	450	0	12	1	120	14	120
	13	2	13	6	600	0	13	0	130	7	130
	14	0	14	1	800	80	14	1	140	15	140
	15	0	15	0	900	0	15	2	150	7	150
	16	0	16	0	1000	0	16	0	160	5	160
	17	0	17	0	1200	0	17	0	170	7	170
	18	0	18	0	1400	0	18	0	180	7	180
	19	0	19	0	1600	0	19	0	190	7	190
	20	0	20	0	1800	0	20	0	200	7	200
	21	0	21	0	2000	0	21	0	210	7	210
	22	0	22	0	2200	0	22	0	220	7	220
	23	0	23	0	2400	0	23	0	230	7	230
	24	0	24	0	2600	0	24	0	240	7	240
	25	0	25	0	2800	0	25	0	250	7	250
	26	0	26	0	3000	0	26	0	260	7	260
	27	0	27	0	3200	0	27	0	270	7	270
	28	0	28	0	3400	0	28	0	280	7	280
	29	0	29	0	3600	0	29	0	290	7	290
	30	0	30	0	3800	0	30	0	300	7	300
	More	0	More	0	More	0	More	0	More	0	More

Run #	46	EvTC	Tev	FASZ	RndT	RndT(C)	MSR	A/Avg(MT)	MSR	MSR(C)	#
SYSTEM	800	Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin
Start Area	0	0	0	0	0	0	0	0	0	0	0
Days	1	0	1	0	1	0	0	0	0	0	0
Loc Time	2	0	2	0	2	0	0	0	0	0	0
Stop Rules	3	0	3	0	3	0	0	0	0	0	0
Shrink %	4	0	4	0	4	0	0	0	0	0	0
Expand Rules	5	0	5	0	5	0	0	0	0	0	0
6-PI Time	6	0	6	0	6	0	0	0	0	0	0
8-PI Time	7	0	7	0	7	0	0	0	0	0	0
Expand %	8	0	8	0	8	0	0	0	0	0	0
1	9	16	9	1	300	0	9	16	90	3	90
200%	10	35	10	16	337	0	10	7	100	7	100
	11	28	11	44	400	1	11	5	110	12	110
	12	16	12	34	450	0	12	0	120	14	120
	13	2	13	4	600	20	13	0	130	7	130
	14	0	14	1	800	79	14	2	140	14	140
	15	0	15	0	900	0	15	0	150	6	150
	16	0	16	0	1000	0	16	0	160	7	160
	17	0	17	0	1200	0	17	0	170	7	170
	18	0	18	0	1400	0	18	0	180	7	180
	19	0	19	0	1600	0	19	0	190	7	190
	20	0	20	0	1800	0	20	0	200	7	200
	21	0	21	0	2000	0	21	0	210	7	210
	22	0	22	0	2200	0	22	0	220	7	220
	23	0	23	0	2400	0	23	0	230	7	230
	24	0	24	0	2600	0	24	0	240	7	240
	25	0	25	0	2800	0	25	0	250	7	250
	26	0	26	0	3000	0	26	0	260	7	260
	27	0	27	0	3200	0	27	0	270	7	270
	28	0	28	0	3400	0	28	0	280	7	280
	29	0	29	0	3600	0	29	0	290	7	290
	30	0	30	0	3800	0	30	0	300	7	300
	More	0	More	0	More	0	More	0	More	0	More

Table B-3. Simulation Results (cont)

Run #	SYSTEM	47	EXTC		Twp	FASZ		RndT		Rnd(C)		MdsR		AAvg(NT)		AAvg(MTC))		MSR		MSRC)	
			#	Bin		#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin
800	Start Area	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
8	Days	1	0	1	0	50	0	1	0	1	0	10	0	10	0	10	0	20	0	20	
8	Loc Time	2	0	2	0	95	0	2	0	2	0	20	0	20	0	20	0	40	0	40	
2	Rego Time	3	0	3	0	100	0	3	0	3	0	30	0	30	0	30	0	60	0	60	
12	Stop Rules	4	0	4	0	127	0	4	0	4	0	40	0	40	0	40	0	80	0	80	
50%	Shrink %	5	0	5	0	169	0	5	1	5	3	50	0	50	0	50	0	100	0	100	
12	Stop Time	6	0	6	0	200	7	6	19	6	30	60	0	60	0	60	0	120	1	120	
50%	Expand Rules	7	0	7	0	225	0	7	28	7	23	70	2	70	2	70	2	140	7	140	
1.5	8-P4 Time	8	0	8	0	253	0	8	18	8	27	80	6	80	6	80	3	160	5	160	
1	5-P4 Time	9	0	9	0	300	0	9	17	9	10	90	7	90	8	90	8	180	14	180	
200%	Expand %	10	28	10	0	337	0	10	8	10	4	100	17	100	16	110	100	9	200	8	
		11	49	11	8	400	50	11	5	11	2	110	13	110	15	110	16	220	10	220	
		12	23	12	41	450	0	12	1	12	1	120	10	120	15	120	11	240	11	240	
		13	0	13	34	600	0	13	2	13	0	130	7	130	14	130	13	260	5	260	
		14	0	14	16	800	0	14	1	14	0	140	10	140	9	140	15	280	6	280	
		15	0	15	1	1200	0	15	0	15	0	150	5	150	7	150	10	300	8	300	
		16	0	16	0	1600	0	16	0	16	0	160	9	160	8	160	10	320	3	320	
		17	0	17	0	1800	0	17	0	17	0	170	9	170	1	170	3	340	4	340	
		18	0	18	0	More	U	18	0	18	0	180	8	180	0	180	1	360	1	360	
		19	0	19	0	More	U	19	0	19	0	190	5	190	0	190	0	380	3	380	
		20	0	20	0	More	U	20	0	20	0	200	2	200	0	200	1	400	1	400	
		21	0	21	0	More	U	21	0	21	0	210	0	210	0	210	0	420	1	420	
		22	0	22	0	More	U	22	0	22	0	220	0	220	0	220	0	440	1	440	
		23	0	23	0	More	U	23	0	23	0	230	1	230	0	230	0	460	2	460	
		24	0	24	0	More	U	24	0	24	0	240	0	240	0	240	0	480	1	480	
		25	0	25	0	More	U	25	0	25	0	250	0	250	0	250	0	500	0	500	
		26	0	26	0	More	U	26	0	26	0	260	3	260	0	260	0	520	0	520	
		27	0	27	0	More	U	27	0	27	0	270	0	270	0	270	0	540	0	540	
		28	0	28	0	More	U	28	0	28	0	280	0	280	0	280	0	560	1	560	
		29	0	29	0	More	U	29	0	29	0	290	0	290	0	290	0	580	0	580	
		30	0	30	0	More	U	30	0	30	0	300	0	300	0	300	0	600	0	600	
		More	U	More	U	More	U	More	U	More	U	310	0	310	0	310	0	620	0	620	
			U		U		U		U		U	320	0	320	0	320	0	640	0	640	
			U		U		U		U		U	330	0	330	0	330	0	660	1	660	
			U		U		U		U		U	340	0	340	0	340	0	680	2	680	
			U		U		U		U		U	350	0	350	0	350	0	700	0	700	
			U		U		U		U		U	More	0	More	0	More	0	More	3	More	
												More	0	More	0	More	0	More	2	More	

Run #	EYC		Tev		FASZ		RndT		RndT(C)		MISR		A/Avg(WT)		A/Avg(NT(C))		MSR		MSR(C)	
	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin
48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SYSTEM	1	1	0	1	0	50	0	1	0	1	0	10	0	10	0	10	0	20	0	20
Start Area	8	2	0	2	0	95	0	3	0	2	0	20	0	20	0	20	0	40	0	40
Days	8	2	0	3	0	190	0	4	1	4	0	30	0	30	0	30	0	60	0	60
Loc Time	2	3	0	4	0	120	0	4	1	4	0	40	0	40	0	40	0	80	0	80
Reg Time	2	3	0	4	0	120	0	4	1	4	0	40	0	40	0	40	0	80	0	80
Stop Rules	12	4	0	4	0	169	0	5	2	5	0	50	0	50	0	50	0	100	0	100
Stop Time	12	4	0	4	0	169	0	5	2	5	0	50	0	50	0	50	0	100	0	100
25%	5	0	0	0	0	200	0	6	15	6	31	60	0	60	0	60	0	120	1	120
Shrink %	6	0	0	0	0	225	0	7	24	7	28	70	2	70	2	70	0	140	9	140
Expand Rules	7	0	0	0	0	253	0	8	22	8	23	80	3	80	3	80	0	160	9	160
6-PT Time	4.5	0	0	0	0	300	0	9	17	9	13	90	4	90	12	90	3	180	9	180
5-PT Time	4	10	32	10	0	337	0	10	10	10	100	3	90	12	90	12	200	10	200	
Expand %	200%	11	41	11	8	400	0	11	7	11	0	110	21	110	18	110	17	220	10	220
		12	9	12	56	450	17	12	0	12	0	120	14	120	9	120	13	260	8	260
		13	1	13	34	600	46	13	1	13	0	130	16	130	15	130	17	240	6	240
		14	1	14	2	800	37	14	1	14	0	140	9	140	8	140	17	280	6	280
		15	0	15	0	900	0	15	0	15	0	150	10	150	4	150	16	300	5	300
		16	0	16	0	1200	0	16	0	16	0	160	4	160	6	160	11	320	3	320
		17	0	17	0	1600	0	17	0	17	0	170	3	170	1	170	3	340	2	340
		18	0	18	0	More	U	18	0	18	0	180	5	180	U	180	1	380	1	380
		19	0	19	0	More	U	19	0	19	0	190	1	190	1	190	1	380	2	380
		20	0	20	0	More	U	20	0	20	0	200	1	200	0	200	0	400	1	400
		21	0	21	0	More	U	21	0	21	0	210	1	210	U	210	0	420	2	420
		22	0	22	0	More	U	22	0	22	0	220	2	220	0	220	0	440	0	440
		23	0	23	0	More	U	23	0	23	0	230	2	230	0	230	0	460	2	460
		24	0	24	0	More	U	24	0	24	0	240	0	240	0	240	0	480	3	480
		25	0	25	0	More	U	25	0	25	0	250	1	250	1	250	1	500	0	500
		26	0	26	0	More	U	26	0	26	0	260	0	260	0	260	0	520	0	520
		27	0	27	0	More	U	27	0	27	0	270	0	270	0	270	0	540	0	540
		28	0	28	0	More	U	28	0	28	0	280	0	280	0	280	0	560	0	560
		29	0	29	0	More	U	29	0	29	0	290	0	290	0	290	0	580	0	580
		30	0	30	0	More	U	30	0	30	0	300	0	300	0	300	0	600	0	600
		More	U	More	U	More	U	More	U	More	U	310	1	310	U	310	U	620	U	620
												320	0	320	0	320	0	640	0	640
												330	0	330	0	330	0	660	1	660
												340	0	340	0	340	0	680	0	680
												350	0	350	0	350	0	700	0	700
												More	U	More	U	More	U	More	3	More

Table B-3. Simulation Results (cont)

Run #	SYSTEM	Start Area	Days	Loc Time	Rego Time	Stop Time	Shrink %	Expand Rules	5-PT Time	Expand %	EvTC	#	Tev	#	FASZ	#	RedT	#	RedTC	#	MSR	#	A/Avg(NT)	#	A/Avg(NTC)	#	MSR	#	MSR(C)	#
49	B	800	4	1	2	3	24	24	50%	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
50	B	800	4	1	2	3	24	24	50%	1.5	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
51	B	800	4	1	2	3	24	24	50%	1.5	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
52	B	800	4	1	2	3	24	24	50%	1.5	3	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
53	B	800	4	1	2	3	24	24	50%	1.5	4	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
54	B	800	4	1	2	3	24	24	50%	1.5	5	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
55	B	800	4	1	2	3	24	24	50%	1.5	6	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
56	B	800	4	1	2	3	24	24	50%	1.5	7	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
57	B	800	4	1	2	3	24	24	50%	1.5	8	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
58	B	800	4	1	2	3	24	24	50%	1.5	9	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
59	B	800	4	1	2	3	24	24	50%	1.5	10	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
60	B	800	4	1	2	3	24	24	50%	1.5	11	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
61	B	800	4	1	2	3	24	24	50%	1.5	12	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
62	B	800	4	1	2	3	24	24	50%	1.5	13	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
63	B	800	4	1	2	3	24	24	50%	1.5	14	0	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
64	B	800	4	1	2	3	24	24	50%	1.5	15	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
65	B	800	4	1	2	3	24	24	50%	1.5	16	0	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
66	B	800	4	1	2	3	24	24	50%	1.5	17	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
67	B	800	4	1	2	3	24	24	50%	1.5	18	0	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
68	B	800	4	1	2	3	24	24	50%	1.5	19	0	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
69	B	800	4	1	2	3	24	24	50%	1.5	20	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
70	B	800	4	1	2	3	24	24	50%	1.5	21	0	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
71	B	800	4	1	2	3	24	24	50%	1.5	22	0	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
72	B	800	4	1	2	3	24	24	50%	1.5	23	0	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
73	B	800	4	1	2	3	24	24	50%	1.5	24	0	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
74	B	800	4	1	2	3	24	24	50%	1.5	25	0	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
75	B	800	4	1	2	3	24	24	50%	1.5	26	0	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
76	B	800	4	1	2	3	24	24	50%	1.5	27	0	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
77	B	800	4	1	2	3	24	24	50%	1.5	28	0	28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
78	B	800	4	1	2	3	24	24	50%	1.5	29	0	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
79	B	800	4	1	2	3	24	24	50%	1.5	30	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
80	B	800	4	1	2	3	24	24	50%	1.5	More	U	More	U	More	U	More	U	More	U	More	U	More	U	More	U	More	U	More	

Table B-3. Simulation Results (cont)

Run #	51	E7C	#	Tev	#	FASz	#	RndT	#	RndT(C)	#	MSR	#	A/Avp(N7)	#	A/Avp(N7(C))	#	MSR	#	MSR(C)	#
SYSTEM	B																				
Start Area	800		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Days	4	1	0	0	1	0	50	0	1	0	1	0	10	0	10	0	10	0	20	0	20
Loc Time	2	3	2	0	95	0	2	0	2	0	2	0	20	0	20	0	20	0	40	1	40
Repo Time	2	3	9	3	0	100	0	3	0	4	0	30	1	30	2	30	0	60	10	60	
Stop Rules		4	3	127	0	4	0	4	0	4	0	40	5	40	5	40	0	80	14	80	
Stop Time	20	5	32	5	24	169	0	5	0	6	0	50	9	50	9	50	0	100	21	100	
Shrink %	50%	6	17	6	47	200	0	7	1	7	0	60	20	60	20	60	18	120	11	120	
Expand Rules		7	5	7	20	225	0	8	3	8	1	70	15	70	15	70	32	140	14	140	
6-PM Time	1.5	8	2	8	5	254	0	9	3	9	4	80	14	80	14	80	16	160	9	160	
Expand %	200%	1	9	1	9	300	0	9	8	9	6	90	10	90	8	90	12	180	2	180	
		10	0	10	0	338	0	10	8	10	12	100	6	100	6	100	6	200	3	200	
		11	0	11	0	400	31	11	13	11	11	110	7	110	7	110	3	220	3	220	
		12	0	12	0	450	0	12	8	12	14	120	0	120	0	120	4	240	2	240	
		13	0	13	0	500	0	13	9	13	18	130	3	130	3	130	1	260	2	260	
		14	0	14	0	600	69	14	8	14	12	140	5	140	5	140	0	280	1	280	
		15	0	15	0	800	0	15	10	15	15	150	0	150	0	150	0	300	2	300	
		16	0	16	0	1200	0	16	9	16	4	160	1	160	1	160	0	320	0	320	
		17	0	17	0	1600	0	17	4	17	3	170	0	170	0	170	0	340	1	340	
		18	0	18	0	1800	0	18	2	18	3	180	0	180	0	180	0	360	0	360	
		19	0	19	0	More	More	19	3	19	2	190	1	190	1	190	0	380	1	380	
		20	0	20	0	More	More	20	5	20	0	200	0	200	0	200	0	400	0	400	
		21	0	21	0	More	More	21	12	More	1	210	0	210	0	210	0	420	1	420	
		22	0	22	0	More	More	22	0	More	0	220	0	220	0	220	0	440	0	440	
		23	0	23	0	More	More	23	0	More	0	230	0	230	0	230	0	460	0	460	
		24	0	24	0	More	More	24	0	More	0	240	0	240	0	240	0	480	0	480	
		25	0	25	0	More	More	25	0	More	0	250	0	250	0	250	0	500	0	500	
		26	0	26	0	More	More	26	0	More	0	260	0	260	0	260	0	520	0	520	
		27	0	27	0	More	More	27	0	More	0	270	0	270	0	270	0	540	0	540	
		28	0	28	0	More	More	28	0	More	0	280	0	280	0	280	0	560	0	560	
		29	0	29	0	More	More	29	0	More	0	290	0	290	0	290	0	580	0	580	
		30	0	30	0	More	More	30	0	More	0	300	0	300	0	300	0	600	0	600	
		More	0	More	0	More	More	More	12	More	1	More	0	More	0	More	0	620	1	620	
																		640	1	640	
																		660	0	660	
																		680	0	680	
																		700	0	700	
																		More	0	More	

SYSTEM	Run #	EVT		Tev		FASZ		RndT		RndT(C)		MSDR		A/Avg(WT)		A/Avg(WT(C))		MSR		MSR(C)	
		#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin
52	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
800	Start Area	1	1	1	0	50	0	1	0	1	0	10	0	10	0	10	0	20	0	20	0
4	Days	2	7	2	0	95	0	2	0	2	0	20	0	20	0	20	0	40	2	40	2
2	Loc Time	3	13	3	0	100	0	3	0	3	0	30	3	30	3	30	3	60	10	60	10
2	Rego Time	4	29	4	4	127	0	4	0	4	0	40	6	40	4	40	4	80	12	80	12
20	Stop Rules	5	26	5	31	169	0	5	0	5	0	50	10	50	10	50	10	100	17	100	17
25%	Shrink %	6	17	6	46	200	0	6	0	6	0	60	17	60	22	60	22	120	20	120	20
1.5	Expand Rules	7	6	7	17	225	0	7	1	7	1	70	16	70	77	70	77	140	10	140	10
1	6-Pr Time	8	0	8	1	254	0	8	2	8	4	80	13	80	13	80	13	160	9	160	9
1	Expand %	9	1	9	1	300	0	9	6	9	6	90	14	90	9	90	9	180	3	180	3
200%		10	0	10	0	338	0	10	9	10	12	100	8	100	8	100	8	200	1	200	1
		11	0	11	0	400	0	11	10	11	11	110	4	110	4	110	4	220	3	220	3
		12	0	12	0	450	3	12	9	12	13	120	1	120	1	120	1	240	3	240	3
		13	0	13	0	600	28	13	8	13	22	130	3	130	3	130	3	260	2	260	2
		14	0	14	0	800	69	14	7	14	11	140	3	140	3	140	3	280	2	280	1
		15	0	15	0	900	0	15	10	15	6	150	0	150	0	150	0	300	2	300	3
		16	0	16	0	1200	0	16	8	16	8	160	1	160	1	160	1	320	0	320	0
		17	0	17	0	1600	0	17	8	17	3	170	0	170	0	170	0	340	1	340	1
		18	0	18	0	More	U	18	1	18	1	180	0	180	0	180	0	360	U	360	U
		19	0	19	0	More	U	19	4	19	0	190	1	190	0	190	0	380	0	380	0
		20	0	20	0	More	U	20	2	20	2	200	0	200	0	200	0	400	1	400	1
		21	0	21	0	More	U	21	15	More	U	210	0	210	0	210	0	420	1	420	1
		22	0	22	0	More	U	22	0	22	0	220	0	220	0	220	0	440	0	440	0
		23	0	23	0	More	U	23	0	23	0	230	0	230	0	230	0	460	0	460	0
		24	0	24	0	More	U	24	0	24	0	240	0	240	0	240	0	480	0	480	0
		25	0	25	0	More	U	25	0	25	0	250	0	250	0	250	0	500	0	500	0
		26	0	26	0	More	U	26	0	26	0	260	0	260	0	260	0	520	0	520	0
		27	0	27	0	More	U	27	0	27	0	270	0	270	0	270	0	540	1	540	1
		28	0	28	0	More	U	28	0	28	0	280	0	280	0	280	0	560	0	560	0
		29	0	29	0	More	U	29	0	29	0	290	0	290	0	290	0	580	0	580	0
		30	0	30	0	More	U	30	0	30	0	300	0	300	0	300	0	600	0	600	0
		More	U	More	U	More	U	More	U	More	U	310	0	310	0	310	0	620	U	620	U
												320	0	320	0	320	0	640	1	640	1
												330	0	330	0	330	0	660	0	660	0
												340	0	340	0	340	0	680	0	680	0
												350	0	350	0	350	0	700	0	700	0
												More	U	More	U	More	U	More	U	More	U

Table B-3. Simulation Results (cont)

Run #	SYSTEM	Start Area	Days	Loc Time	Rego Time	Stop Rules	Shrink %	Expand Rules	6-PI Time	5-PI Time	Expand %	EvTC		Tev		FASz		RndT		RndT(C)		MSR		A/Avp(NT)		A/Avg(NT(C))		MSR		MSR(C)	
												#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin
53	B	800	4	2	3	4	22	54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
800	4	2	3	4	22	54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
4	2	3	4	22	54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2	3	4	22	54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
16	5	30	5	4	169	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5
50%	6	26	6	36	200	10	6	0	6	0	6	0	6	0	6	0	6	0	6	0	6	0	6	0	6	0	6	0	6	0	6
1.5	7	8	7	34	225	0	7	1	7	1	7	1	7	1	7	1	7	1	7	1	7	1	7	1	7	1	7	1	7	1	7
1	8	2	8	22	254	0	8	2	8	2	8	2	8	2	8	2	8	2	8	2	8	2	8	2	8	2	8	2	8	2	8
200%	9	1	9	4	300	0	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
	10	0	10	0	338	0	10	8	10	8	10	8	10	8	10	8	10	8	10	8	10	8	10	8	10	8	10	8	10	8	10
	11	0	11	0	400	51	11	5	11	5	11	5	11	5	11	5	11	5	11	5	11	5	11	5	11	5	11	5	11	5	11
	12	0	12	0	450	0	12	8	12	8	12	8	12	8	12	8	12	8	12	8	12	8	12	8	12	8	12	8	12	8	12
	13	0	13	0	600	0	13	12	13	12	13	12	13	12	13	12	13	12	13	12	13	12	13	12	13	12	13	12	13	12	13
	14	0	14	0	800	39	14	11	14	11	14	11	14	11	14	11	14	11	14	11	14	11	14	11	14	11	14	11	14	11	14
	15	0	15	0	900	0	15	5	15	5	15	5	15	5	15	5	15	5	15	5	15	5	15	5	15	5	15	5	15	5	15
	16	0	16	0	1200	0	16	9	16	9	16	9	16	9	16	9	16	9	16	9	16	9	16	9	16	9	16	9	16	9	16
	17	0	17	0	1600	0	17	3	17	3	17	3	17	3	17	3	17	3	17	3	17	3	17	3	17	3	17	3	17	3	17
	18	0	18	0	More	0	18	7	18	7	18	7	18	7	18	7	18	7	18	7	18	7	18	7	18	7	18	7	18	7	18
	19	0	19	0	More	0	19	3	19	3	19	3	19	3	19	3	19	3	19	3	19	3	19	3	19	3	19	3	19	3	19
	20	0	20	0	More	0	20	3	20	3	20	3	20	3	20	3	20	3	20	3	20	3	20	3	20	3	20	3	20	3	20
	21	0	21	0	More	0	21	14	21	14	21	14	21	14	21	14	21	14	21	14	21	14	21	14	21	14	21	14	21	14	21
	22	0	22	0	More	0	22	More	22	More	22	More	22	More	22	More	22	More	22	More	22	More	22	More	22	More	22	More	22	More	22
	23	0	23	0	More	0	23	More	23	More	23	More	23	More	23	More	23	More	23	More	23	More	23	More	23	More	23	More	23	More	23
	24	0	24	0	More	0	24	More	24	More	24	More	24	More	24	More	24	More	24	More	24	More	24	More	24	More	24	More	24	More	24
	25	0	25	0	More	0	25	More	25	More	25	More	25	More	25	More	25	More	25	More	25	More	25	More	25	More	25	More	25	More	25
	26	0	26	0	More	0	26	More	26	More	26	More	26	More	26	More	26	More	26	More	26	More	26	More	26	More	26	More	26	More	26
	27	0	27	0	More	0	27	More	27	More	27	More	27	More	27	More	27	More	27	More	27	More	27	More	27	More	27	More	27	More	27
	28	0	28	0	More	0	28	More	28	More	28	More	28	More	28	More	28	More	28	More	28	More	28	More	28	More	28	More	28	More	28
	29	0	29	0	More	0	29	More	29	More	29	More	29	More	29	More	29	More	29	More	29	More	29	More	29	More	29	More	29	More	29
	30	0	30	0	More	0	30	More	30	More	30	More	30	More	30	More	30	More	30	More	30	More	30	More	30	More	30	More	30	More	30
	More	U	More	U	More	U	More	U	More	U	More	U	More	U	More	U	More	U	More	U	More	U	More	U	More	U	More	U	More	U	More

Run #	SYSTEM	B	54	EYTC		Tev	FASz		RndT		RndT(C)		MSR	A/Avp(NT)		#	A/Avp(NT(C))		#	MSR		#	MSR(C)	
				Bin	#		Bin	#	Bin	#	Bin	#		Bin	#		Bin	#		Bin	#		Bin	#
800	START Area	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	Days	1	0	1	0	0	0	50	1	0	1	0	10	0	10	0	10	0	20	0	20	0	20	0
2	Loc Time	2	8	2	0	0	0	95	2	0	2	0	30	0	30	0	30	0	40	1	40	1	40	0
2	Rego Time	3	14	3	0	100	0	3	0	3	0	3	0	30	0	30	0	40	0	40	0	40	5	
16	Stop Rules	4	25	4	0	127	0	4	0	4	0	4	0	40	0	40	0	40	0	80	11	80	16	
25%	Shrink %	5	26	5	9	169	0	5	0	5	0	5	0	50	0	50	0	50	0	100	25	100	21	
Expand Rules	6-PI Time	6	21	6	44	200	0	6	1	6	1	6	1	60	15	60	12	60	11	120	13	120	18	
		7	4	7	36	225	0	7	0	7	0	7	0	70	14	70	23	70	23	140	11	140	11	
1.5	8-PI Time	8	1	8	9	254	0	8	2	8	2	8	3	80	16	80	11	80	16	160	9	160	10	
1	Expand %	9	1	9	2	300	0	9	4	9	13	90	12	90	90	9	100	12	200	5	200	4		
200%		10	0	10	0	338	2	10	9	10	10	19	100	6	110	100	4	110	100	3	220	2	220	3
		11	0	11	0	400	0	11	8	11	11	19	110	6	120	110	6	120	110	3	240	2	240	3
		12	0	12	0	450	15	12	13	12	14	120	4	130	120	4	130	120	3	260	1	260	2	
		13	0	13	0	600	45	13	11	13	14	130	2	140	130	2	140	130	0	280	3	280	2	
		14	0	14	0	800	38	14	12	14	8	140	3	150	140	3	150	140	1	300	0	300	1	
		15	0	15	0	900	0	15	6	15	6	150	0	160	150	0	160	150	1	320	0	320	0	
		16	0	16	0	1200	0	16	12	16	1	160	1	170	160	1	170	160	0	340	1	340	1	
		17	0	17	0	1600	0	17	6	17	1	170	0	180	170	0	180	170	0	360	0	360	0	
		18	0	18	0	More	U	More	U	18	2	180	0	190	180	0	190	180	0	380	0	380	0	
		19	0	19	0	More	U	More	U	19	2	190	0	200	190	0	200	190	0	400	0	400	0	
		20	0	20	0	More	U	More	U	20	7	200	0	210	200	0	210	200	0	420	1	420	1	
		21	0	21	0	More	U	More	U	21	11	More	U	220	210	0	220	210	0	440	1	440	1	
		22	0	22	0	More	U	More	U	22	0	More	U	230	220	0	230	220	0	460	1	460	1	
		23	0	23	0	More	U	More	U	23	0	More	U	240	230	0	240	230	0	480	0	480	0	
		24	0	24	0	More	U	More	U	24	0	More	U	250	240	1	250	240	0	500	0	500	0	
		25	0	25	0	More	U	More	U	25	0	More	U	260	250	0	260	250	0	520	0	520	0	
		26	0	26	0	More	U	More	U	26	0	More	U	270	260	0	270	260	0	540	0	540	0	
		27	0	27	0	More	U	More	U	27	0	More	U	280	270	0	280	270	0	560	1	560	1	
		28	0	28	0	More	U	More	U	28	0	More	U	290	280	0	290	280	0	580	0	580	0	
		29	0	29	0	More	U	More	U	29	0	More	U	300	290	0	300	290	0	600	0	600	0	
		30	0	30	0	More	U	More	U	30	0	More	U	310	300	0	310	300	0	620	0	620	0	
		More	U	More	U	More	U	More	U	More	U	More	U	320	310	0	320	310	0	640	0	640	0	
														330	320	0	330	320	0	660	0	660	0	
														340	330	0	340	330	0	680	0	680	0	
														350	340	0	350	340	0	700	0	700	0	
														More	350	0	More	350	0	More	0	More	0	

Table B-3. Simulation Results (cont)

55	Run #	EoTC		Taw		FASz		RadT		RadT(C)		MidSR	A/Avg(N/T)		MSR	A/Avg(NT/Ct)		MSR	MSR(N)	
		Bin	#	Bin	#	Bin	#	Bin	#	Bin	#		Bin	#		Bin	#		Bin	#
800	SYSTEM	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B	Start Area	1	0	1	0	50	0	1	0	1	0	10	0	10	0	10	0	20	0	20
4	Days	2	0	2	0	95	0	2	0	2	0	20	0	20	0	20	0	40	0	40
2	Loc Time	3	0	3	0	100	0	3	0	3	0	30	1	30	2	30	0	60	7	60
2	Stop Rules	4	1	4	0	127	0	4	0	4	0	40	5	40	0	40	0	80	19	60
12	Stop Time	5	27	5	0	169	0	5	0	4	0	50	13	50	22	50	4	100	16	100
59%	Shrink %	6	37	6	0	200	46	6	0	6	0	60	19	60	28	60	8	120	17	120
	Expand Rules	7	26	7	8	225	0	7	1	7	7	2	70	70	19	70	20	140	15	140
4.5	6-Pr Time	8	9	8	40	254	0	8	3	8	6	80	19	80	19	80	28	160	7	160
1	5-Pr Time	9	0	9	36	300	0	9	5	9	10	90	9	90	3	90	21	180	5	180
200%	Expand %	10	0	10	14	338	0	10	3	10	20	100	7	100	5	100	1	200	4	200
		11	0	11	2	400	45	11	5	11	22	110	3	110	3	110	4	220	2	220
		12	0	12	0	450	0	12	15	12	15	130	3	130	1	130	2	240	1	240
		13	0	13	0	600	0	13	7	13	12	130	3	130	0	130	2	260	2	260
		14	0	14	0	800	0	14	8	14	7	140	0	140	0	140	0	280	2	280
		15	0	15	0	900	0	15	16	15	1	150	0	150	0	150	0	300	0	300
		16	0	16	0	1000	0	16	17	16	1	160	0	160	0	160	0	320	1	320
		17	0	17	0	1200	0	17	5	17	2	170	0	170	0	170	0	340	0	340
		18	0	18	0	1600	0	18	6	18	2	180	0	180	0	180	0	360	0	360
		19	0	19	0	More	U	19	8	19	0	190	0	190	0	190	0	380	0	380
		20	0	20	0	More	U	20	3	20	0	200	0	200	0	200	0	400	1	400
		21	U	21	U	More	8	21	U	More	U	210	0	210	0	210	0	420	1	420
		22	0	22	0	More	8	22	0	22	0	220	0	220	0	220	0	440	0	440
		23	0	23	0	More	8	23	0	23	0	230	0	230	0	230	0	460	0	460
		24	0	24	0	More	8	24	0	24	0	240	0	240	0	240	0	480	0	480
		25	0	25	0	More	8	25	0	25	0	250	0	250	0	250	0	500	1	500
		26	0	26	0	More	8	26	0	26	0	260	0	260	0	260	0	520	0	520
		27	0	27	0	More	8	27	0	27	0	270	0	270	0	270	0	540	0	540
		28	0	28	0	More	8	28	0	28	0	280	0	280	0	280	0	560	0	560
		29	0	29	0	More	8	29	0	29	0	290	0	290	0	290	0	580	0	580
		30	U	30	U	More	8	30	U	More	U	300	0	300	0	300	0	600	0	600
		More	U	More	U	More	8	More	U	More	U	310	0	310	0	310	0	620	0	620
												320	0	320	0	320	0	640	0	640
												330	0	330	0	330	0	660	0	660
												340	0	340	0	340	0	680	0	680
												350	0	350	0	350	0	700	0	700
												More	U	More	U	More	U	More	U	More

58	Run #	EVC		Tev		FASZ		RndT		RndT(C)		MSR		A/Avg(MT)		A/Avg(MT(C))		MSR		MSR(C)	
		#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin
SYSTEM	800	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		1	0	1	0	50	0	1	0	1	0	10	0	10	0	10	0	20	0	20	0
Start Area	4	2	1	2	0	95	0	2	0	20	0	30	0	20	0	20	0	40	1	40	0
Days	2	3	7	3	0	100	0	3	0	30	0	20	0	30	0	30	0	60	7	60	0
Loc Time	2	4	37	4	0	127	0	4	0	40	0	40	0	40	0	40	0	80	16	80	12
Rego Time	2	5	23	5	0	169	0	5	0	50	0	50	0	50	0	50	0	100	15	100	21
Stop Rules	12	6	24	6	0	200	0	6	0	60	0	60	0	60	0	60	0	120	17	120	13
Shrink %	25%	7	6	7	28	225	0	7	0	70	0	70	0	70	0	70	0	140	12	140	19
Stop Time	25%	8	2	8	51	254	4	8	2	80	0	80	0	80	0	80	0	160	7	160	8
Expand Rules	1.5	9	0	9	21	300	0	9	5	90	0	90	0	90	0	90	0	180	6	180	4
8-PM Time	1	10	0	10	0	338	16	10	10	100	0	100	0	100	0	100	0	200	6	200	8
Expand %	200%	11	0	11	0	400	0	11	7	110	6	110	6	110	6	110	6	220	5	220	1
		12	0	12	0	450	39	12	10	120	12	120	12	120	12	120	12	240	3	240	4
		13	0	13	0	600	31	13	10	130	3	130	2	130	0	130	0	260	2	260	3
		14	0	14	0	800	10	14	7	140	2	140	1	140	0	140	0	280	1	280	0
		15	0	15	0	900	0	15	8	150	0	150	0	150	0	150	0	300	1	300	0
		16	0	16	0	1200	0	16	9	160	0	160	0	160	0	160	0	320	0	320	1
		17	0	17	0	1600	0	17	5	170	0	170	0	170	0	170	0	340	1	340	1
		18	0	18	0	More	0	18	4	180	0	180	0	180	0	180	0	360	1	360	0
		19	0	19	0	More	0	19	4	190	0	190	0	190	0	190	0	380	0	380	0
		20	0	20	0	More	6	20	6	200	0	200	0	200	0	200	0	400	0	400	0
		21	0	21	0	More	13	21	6	210	0	210	0	210	0	210	0	420	1	420	2
		22	0	22	0	More	13	22	0	220	0	220	0	220	0	220	0	440	0	440	0
		23	0	23	0	More	13	23	0	230	0	230	0	230	0	230	0	460	0	460	0
		24	0	24	0	More	13	24	0	240	0	240	0	240	0	240	0	480	0	480	0
		25	0	25	0	More	13	25	0	250	0	250	0	250	0	250	0	500	1	500	1
		26	0	26	0	More	13	26	0	260	0	260	0	260	0	260	0	520	0	520	0
		27	0	27	0	More	13	27	0	270	0	270	0	270	0	270	0	540	0	540	0
		28	0	28	0	More	13	28	0	280	0	280	0	280	0	280	0	560	0	560	0
		29	0	29	0	More	13	29	0	290	0	290	0	290	0	290	0	580	0	580	0
		30	0	30	0	More	13	30	0	300	0	300	0	300	0	300	0	600	0	600	0
		More	0	More	0	More	13	More	13	310	0	310	0	310	0	310	0	620	0	620	0
		More	0	More	0	More	13	More	13	320	0	320	0	320	0	320	0	640	0	640	0
		More	0	More	0	More	13	More	13	330	0	330	0	330	0	330	0	660	0	660	0
		More	0	More	0	More	13	More	13	340	0	340	0	340	0	340	0	680	0	680	0
		More	0	More	0	More	13	More	13	350	0	350	0	350	0	350	0	700	0	700	0
		More	0	More	0	More	13	More	13	360	0	360	0	360	0	360	0	720	0	720	0
		More	0	More	0	More	13	More	13	370	0	370	0	370	0	370	0	740	0	740	0
		More	0	More	0	More	13	More	13	380	0	380	0	380	0	380	0	760	0	760	0
		More	0	More	0	More	13	More	13	390	0	390	0	390	0	390	0	780	0	780	0
		More	0	More	0	More	13	More	13	400	0	400	0	400	0	400	0	800	0	800	0
		More	0	More	0	More	13	More	13	410	0	410	0	410	0	410	0	820	0	820	0
		More	0	More	0	More	13	More	13	420	0	420	0	420	0	420	0	840	0	840	0
		More	0	More	0	More	13	More	13	430	0	430	0	430	0	430	0	860	0	860	0
		More	0	More	0	More	13	More	13	440	0	440	0	440	0	440	0	880	0	880	0
		More	0	More	0	More	13	More	13	450	0	450	0	450	0	450	0	900	0	900	0
		More	0	More	0	More	13	More	13	460	0	460	0	460	0	460	0	920	0	920	0
		More	0	More	0	More	13	More	13	470	0	470	0	470	0	470	0	940	0	940	0
		More	0	More	0	More	13	More	13	480	0	480	0	480	0	480	0	960	0	960	0
		More	0	More	0	More	13	More	13	490	0	490	0	490	0	490	0	980	0	980	0
		More	0	More	0	More	13	More	13	500	0	500	0	500	0	500	0	1000	0	1000	0

Table B-3. Simulation Results (cont)

Table B-3. Simulation Results (cont)

Run #	EvTC	Tev	FASz	RndT	RndTC	MSR	A/Avg(RT)	MSR	MSRC	#
SYSTEM	Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin
Start Area	0	0	0	0	0	0	0	0	0	0
Days	1	0	0	0	0	10	0	0	0	0
Loc Time	2	3	2	0	2	20	0	20	0	0
Repo Time	3	28	3	0	3	30	0	60	19	15
Stop Rules	4	32	4	0	4	40	13	80	9	12
Shrink %	5	23	5	0	5	50	11	100	19	100
Expand Rules	6	10	6	29	6	60	11	160	10	120
5-PI Time	7	4	7	6	7	70	16	270	11	140
Expand %	8	0	8	0	8	80	13	80	14	10
5-PI Time	9	0	9	0	9	90	13	90	9	180
Expand %	10	0	10	0	10	100	5	100	6	200
5-PI Time	11	0	11	0	11	110	5	110	6	220
Expand %	12	0	12	0	12	120	3	120	3	240
5-PI Time	13	0	13	0	13	130	3	130	1	260
Expand %	14	0	14	0	14	140	1	140	0	280
5-PI Time	15	0	15	0	15	150	1	150	0	300
Expand %	16	0	16	0	16	160	2	160	0	320
5-PI Time	17	0	17	0	17	170	0	170	0	340
Expand %	18	0	18	0	18	180	1	180	0	360
5-PI Time	19	0	19	0	19	190	1	190	0	380
Expand %	20	0	20	0	20	200	1	200	0	400
5-PI Time	21	0	21	0	21	210	1	210	0	420
Expand %	22	0	22	0	22	220	0	220	0	440
5-PI Time	23	0	23	0	23	230	0	230	0	460
Expand %	24	0	24	0	24	240	0	240	0	480
5-PI Time	25	0	25	0	25	250	0	250	0	500
Expand %	26	0	26	0	26	260	0	260	0	520
5-PI Time	27	0	27	0	27	270	0	270	0	540
Expand %	28	0	28	0	28	280	0	280	0	560
5-PI Time	29	0	29	0	29	290	0	290	0	580
Expand %	30	0	30	0	30	300	0	300	0	600
5-PI Time	More	U	More	U	More	310	U	620	1	620
Expand %	More	U	More	U	More	320	0	640	1	640
5-PI Time	More	U	More	U	More	330	0	660	0	660
Expand %	More	U	More	U	More	340	0	680	0	680
5-PI Time	More	U	More	U	More	350	0	700	0	700
Expand %	More	U	More	U	More	More	U	More	U	More

Run #	EvTC	Tev	FASz	RndT	RndTC	MSR	A/Avg(RT)	MSR	MSRC	#
SYSTEM	Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin
Start Area	0	0	0	0	0	0	0	0	0	0
Days	1	1	0	0	0	10	0	0	0	0
Loc Time	2	14	2	0	2	20	0	40	3	14
Repo Time	3	18	3	0	3	30	0	60	14	60
Stop Rules	4	33	4	0	4	40	10	80	15	80
Shrink %	5	16	5	0	5	50	9	100	14	100
Expand Rules	6	11	6	25	6	60	15	180	16	120
5-PI Time	7	7	7	8	7	70	16	280	17	140
Expand %	8	0	8	0	8	80	10	140	5	180
5-PI Time	9	0	9	0	9	90	7	160	7	180
Expand %	10	0	10	0	10	100	8	180	7	180
5-PI Time	11	0	11	0	11	110	8	200	1	200
Expand %	12	0	12	0	12	120	5	220	2	220
5-PI Time	13	0	13	0	13	130	3	240	2	240
Expand %	14	0	14	0	14	140	2	260	3	260
5-PI Time	15	0	15	0	15	150	2	280	3	280
Expand %	16	0	16	0	16	160	1	300	2	300
5-PI Time	17	0	17	0	17	170	0	320	1	320
Expand %	18	0	18	0	18	180	1	340	1	340
5-PI Time	19	0	19	1	19	190	1	360	1	360
Expand %	20	0	20	0	20	200	0	380	1	380
5-PI Time	21	0	21	0	21	210	0	400	0	400
Expand %	22	0	22	0	22	220	0	420	0	420
5-PI Time	23	0	23	0	23	230	0	440	0	440
Expand %	24	0	24	0	24	240	0	460	0	460
5-PI Time	25	0	25	0	25	250	0	480	0	480
Expand %	26	0	26	0	26	260	0	500	0	500
5-PI Time	27	0	27	0	27	270	0	520	0	520
Expand %	28	0	28	0	28	280	0	540	0	540
5-PI Time	29	0	29	0	29	290	0	560	0	560
Expand %	30	0	30	0	30	300	0	580	0	580
5-PI Time	More	U	More	U	More	310	U	600	0	600
Expand %	More	U	More	U	More	320	0	620	1	640
5-PI Time	More	U	More	U	More	330	0	640	0	660
Expand %	More	U	More	U	More	340	0	660	0	680
5-PI Time	More	U	More	U	More	350	0	680	0	700
Expand %	More	U	More	U	More	More	U	More	U	More

Table B-3. Simulation Results (cont)

Table B-3. Simulation Results (cont)

Run #	EUTC		Tev		FASZ		RadT		RadT(G)		mSSE		ΔAve(nT)		ΔAve(nT)		ΔAve(nT)		ΔAve(nT)	
	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#
63	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
800	1	0	1	0	50	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
Start Area	2	0	2	0	95	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0
Days	4	2	3	3	100	1	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Loc Time	2	3	3	0	127	0	3	0	4	0	4	0	4	0	4	0	4	0	4	0
Repo Time	4	16	4	0	127	0	4	0	4	0	4	0	4	0	4	0	4	0	4	0
Stop Rules	12	5	47	5	7	169	0	5	0	5	0	5	0	5	0	5	0	5	0	5
Stop Time	50%	6	30	7	205	35	6	0	6	0	6	0	6	0	6	0	6	0	6	0
Shrink %	1	7	4	8	244	0	7	2	7	2	7	2	7	2	7	2	7	2	7	2
Expand Rules	1.5	8	0	8	44	0	8	2	8	2	8	2	8	2	8	2	8	2	8	2
8-PT Time	1	8	0	9	300	0	9	4	9	4	9	4	9	4	9	4	9	4	9	4
5-PT Time	200%	10	0	10	0	338	0	10	4	10	4	10	4	10	4	10	4	10	4	10
Expand %		11	0	11	0	430	50	11	9	11	16	110	100	11	100	110	100	11	100	110
		12	0	12	0	450	0	12	6	12	15	120	2	12	2	120	2	12	2	120
		13	0	13	0	600	0	13	14	13	130	4	130	4	130	4	130	4	130	4
		14	0	14	0	800	14	14	10	14	4	140	3	140	3	140	3	140	3	140
		15	0	15	0	900	0	15	11	15	2	150	1	150	1	150	1	150	1	150
		16	0	16	0	1200	0	16	6	16	2	160	0	160	0	160	0	160	0	160
		17	0	17	0	1600	0	17	8	17	1	170	0	170	0	170	0	170	0	170
		18	0	18	0	More	U	18	6	18	0	180	0	180	0	180	0	180	0	180
		19	0	19	0	More	U	19	5	19	0	190	0	190	0	190	0	190	0	190
		20	0	20	0	More	U	20	2	20	0	200	0	200	0	200	0	200	0	200
		21	U	21	U	More	U	21	11	More	U	210	0	210	0	210	0	210	0	210
		22	0	22	0	More	U	22	11	More	U	220	0	220	0	220	0	220	0	220
		23	0	23	0	More	U	23	11	More	U	230	0	230	0	230	0	230	0	230
		24	0	24	0	More	U	24	11	More	U	240	0	240	0	240	0	240	0	240
		25	0	25	0	More	U	25	11	More	U	250	0	250	0	250	0	250	0	250
		26	0	26	0	More	U	26	11	More	U	260	0	260	0	260	0	260	0	260
		27	0	27	0	More	U	27	11	More	U	270	0	270	0	270	0	270	0	270
		28	0	28	0	More	U	28	11	More	U	280	0	280	0	280	0	280	0	280
		29	0	29	0	More	U	29	11	More	U	290	0	290	0	290	0	290	0	290
		30	0	30	0	More	U	30	11	More	U	310	0	310	0	310	0	310	0	310
None		More	U	More	U	More	U	More	11	More	U	More	U	More	U	More	U	More	U	More

Run #	EVC		Tev		FASz		RndT		RndT(C)		MGR		A/Avg(MT)		MGR(C)	
	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#
64																
SYSTEM	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Start Area	800	1	0	1	0	1	0	1	0	1	0	10	0	10	0	20
Days	4	1	0	1	0	95	0	1	0	1	0	20	0	20	0	40
Loc Time	4	2	4	2	0	2	0	2	0	2	0	30	1	30	7	60
Regio Time	2	3	22	3	0	100	0	3	0	3	0	40	0	40	72	17
Stop Rules	4	43	4	0	4	127	0	4	0	4	0	50	6	50	80	100
Stop Time	12	5	20	5	0	169	0	5	0	5	0	60	10	60	119	24
Shrink %	25%	6	8	6	12	200	0	6	0	6	2	60	24	60	90	11
Expand Rules	7	3	7	69	225	0	7	3	7	3	7	20	70	25	140	14
8-PM Time	1.5	8	0	8	19	254	2	8	1	8	5	80	15	80	35	9
Expand %	200%	1	9	0	9	300	0	9	6	9	26	90	5	90	160	9
		10	0	10	0	338	14	10	5	10	33	100	7	100	180	9
		11	0	11	0	400	0	11	4	11	18	110	7	110	200	9
		12	0	12	0	450	31	12	8	12	10	120	3	120	220	2
		13	0	13	0	600	41	13	14	13	2	130	1	130	260	1
		14	0	14	0	800	12	14	9	14	0	140	1	140	280	2
		15	0	15	0	900	0	15	6	15	1	150	1	150	300	0
		16	0	16	0	1200	0	16	15	16	0	160	2	160	320	0
		17	0	17	0	1600	0	17	6	17	0	170	0	170	340	1
		18	0	18	0	More	0	18	5	18	0	180	0	180	360	0
		19	0	19	0	More	0	19	4	19	0	190	0	190	380	0
		20	0	20	0	More	0	20	4	20	0	200	0	200	400	1
		21	0	21	0	More	10	21	0	More	0	210	0	210	420	0
		22	0	22	0	More	10	22	0	More	0	220	0	220	440	1
		23	0	23	0	More	10	23	0	More	0	230	0	230	460	0
		24	0	24	0	More	10	24	0	More	0	240	0	240	480	1
		25	0	25	0	More	10	25	0	More	0	250	0	250	500	0
		26	0	26	0	More	10	26	0	More	0	260	0	260	520	0
		27	0	27	0	More	10	27	0	More	0	270	0	270	540	0
		28	0	28	0	More	10	28	0	More	0	280	0	280	560	1
		29	0	29	0	More	10	29	0	More	0	290	0	290	580	0
		30	0	30	0	More	10	30	0	More	0	300	0	300	600	0
		More	0	More	0	More	10	More	0	More	0	310	0	310	620	0
												320	0	320	640	0
												330	0	330	660	0
												340	0	340	680	0
												350	0	350	700	0
												More	0	More	700	0
												More	0	More	More	More

Table B-3. Simulation Results (cont)

Table B-3. Simulation Results (cont)

[illegible]B-37

Run #	B	EVT	Tev		FASz		RadT		RadT(C)		MdsR		A/Avg(WT)		A/Avg(RT(C))		MSR		MSR(C)	
			#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin
SYSTEM	800	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Start Area	4	1	4	1	0	50	0	1	0	1	0	10	0	10	0	10	0	20	0	
Days	4	2	19	2	0	95	0	2	0	2	0	30	0	30	0	40	6	40	2	
Loc Time	6	3	35	3	2	100	0	3	0	3	0	30	4	30	5	20	0	60	13	
Rego Time	2	4	29	4	59	127	0	4	0	4	0	40	9	40	2	60	0	80	18	
Stop Rules	20	5	12	5	37	169	0	5	1	6	1	50	23	50	23	90	0	100	22	
Shrink %	25%	6	1	6	2	200	0	6	2	6	2	60	17	60	20	70	28	120	13	
Expand Rules	1.5	7	0	7	0	225	0	7	1	7	1	70	15	70	10	80	140	6	140	
6-PM Time	1	8	0	8	0	254	0	8	4	8	7	80	12	80	8	90	160	7	160	
Expand %	200%	9	0	9	0	300	0	9	8	9	8	90	9	90	9	100	180	5	180	
		10	0	10	0	336	0	10	7	10	7	100	3	100	7	110	200	4	200	
		11	0	11	0	400	0	11	6	11	13	110	3	110	4	120	240	0	240	
		12	0	12	0	450	1	12	2	12	8	120	4	120	1	130	240	0	240	
		13	0	13	0	600	24	13	7	13	17	130	3	130	0	140	280	2	280	
		14	0	14	0	800	75	14	8	14	12	140	2	140	1	150	300	1	300	
		15	0	15	0	900	0	15	10	15	6	150	1	150	0	160	320	1	320	
		16	0	16	0	1200	0	16	6	16	8	160	1	160	0	170	340	2	340	
		17	0	17	0	1600	0	17	9	17	2	170	1	170	0	180	360	0	360	
		18	0	18	0	More	U	18	10	18	4	180	0	180	1	190	380	0	380	
		19	0	19	0	More	U	19	1	19	2	190	1	190	0	200	400	0	400	
		20	0	20	0	More	U	20	5	20	2	200	0	200	0	210	420	1	420	
		21	0	21	0	More	14	More	14	More	U	210	2	210	0	220	440	0	440	
		22	0	22	0	More	23	More	23	0	220	0	220	0	230	0	460	0	460	
		23	0	23	0	More	24	More	24	0	230	0	230	0	240	0	480	0	480	
		24	0	24	0	More	25	More	25	0	240	0	240	0	250	0	500	0	500	
		25	0	25	0	More	26	More	26	0	250	1	250	0	260	0	520	0	520	
		26	0	26	0	More	27	More	27	0	260	1	260	0	270	0	540	0	540	
		27	0	27	0	More	28	More	28	0	270	0	270	0	280	0	560	0	560	
		28	0	28	0	More	29	More	29	0	280	0	280	0	290	0	580	0	580	
		29	0	29	0	More	30	More	30	0	290	0	290	0	300	0	600	0	600	
		30	0	30	0	More	U	30	0	30	0	300	0	310	0	310	620	0	620	
		More	U	More	U	More	U	More	U	More	U	320	0	320	0	330	640	2	640	
												330	0	330	0	340	660	0	660	
												340	0	340	0	350	680	0	680	
												350	0	350	0	360	700	0	700	
												More	U	More	U	More	U	More	U	

Table B-3. Simulation Results (cont)

Table B-3. Simulation Results (cont)

Run #	SYSTEM	Start Area	Days	Loc Time	Rego Time	Stop Rules	Stop Time	Shrink %	Expand Rules	8-PM Time	Expand %	EVC		Tew		FASz		RadT		RadT(C)		MSR		A/Avp(MT)		A/Avp(MT(C))		MSR		MSR(C)		
												#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#
71	B	800	4	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
8			2	3	37	3	0	100	0	95	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
2			4	53	4	1	127	0	4	0	4	0	4	0	4	0	4	0	4	0	4	0	4	0	4	0	4	0	4	0	4	
42			5	9	5	21	169	0	0	5	1	5	1	5	1	5	1	5	1	5	1	5	1	5	1	5	1	5	1	5	1	
50%			6	1	6	74	200	18	6	0	6	1	6	0	6	1	6	0	6	1	6	0	6	1	6	0	6	1	6	0	6	
1			7	0	7	4	225	0	7	4	7	4	7	4	7	4	7	4	7	4	7	4	7	4	7	4	7	4	7	4	7	
1.5			8	0	8	0	254	0	8	2	8	6	8	2	8	6	8	2	8	6	8	2	8	6	8	2	8	6	8	2	8	
200%			9	0	9	0	330	0	9	2	9	20	9	2	9	20	9	2	9	20	9	2	9	20	9	2	9	20	9	2	9	
			10	0	10	0	400	59	11	10	11	12	11	10	11	12	11	10	11	12	11	10	11	12	11	10	11	12	11	10	11	
			11	0	11	0	450	0	12	11	12	11	12	11	12	11	12	11	12	11	12	11	12	11	12	11	12	11	12	11	12	
			12	0	12	0	450	0	13	7	13	13	13	7	13	11	13	0	14	0	14	0	14	0	14	0	14	0	14	0	14	
			13	0	13	0	800	0	14	7	14	14	7	14	4	14	0	14	0	14	0	14	0	14	0	14	0	14	0	14	0	
			14	0	14	0	800	23	14	7	14	14	7	14	4	14	0	14	0	14	0	14	0	14	0	14	0	14	0	14	0	
			15	0	15	0	900	0	15	8	15	15	8	15	2	15	0	16	0	16	0	16	0	16	0	16	0	16	0	16	0	
			16	0	16	0	1200	0	16	7	16	16	7	16	2	16	0	17	0	17	0	17	0	17	0	17	0	17	0	17	0	
			17	0	17	0	1600	0	17	6	17	17	6	17	0	17	0	18	1	18	1	18	1	18	1	18	1	18	1	18	1	
			18	0	18	0	More	0	18	4	18	18	4	18	0	18	1	18	1	18	1	18	1	18	1	18	1	18	1	18	1	
			19	0	19	0	More	0	19	5	19	0	19	0	19	2	19	0	19	0	19	0	19	0	19	0	19	0	19	0	19	0
			20	0	20	0	More	0	20	7	20	0	20	0	20	0	20	0	20	0	20	0	20	0	20	0	20	0	20	0	20	0
			21	0	21	0	More	0	21	12	More	0	21	0	21	0	21	0	21	0	21	0	21	0	21	0	21	0	21	0	21	0
			22	0	22	0	More	0	22	12	More	0	22	0	22	0	22	0	22	0	22	0	22	0	22	0	22	0	22	0	22	0
			23	0	23	0	More	0	23	12	More	0	23	0	23	0	23	0	23	0	23	0	23	0	23	0	23	0	23	0	23	0
			24	0	24	0	More	0	24	12	More	0	24	0	24	0	24	0	24	0	24	0	24	0	24	0	24	0	24	0	24	0
			25	0	25	0	More	0	25	12	More	0	25	0	25	0	25	0	25	0	25	0	25	0	25	0	25	0	25	0	25	0
			26	0	26	0	More	0	26	12	More	0	26	0	26	0	26	0	26	0	26	0	26	0	26	0	26	0	26	0	26	0
			27	0	27	0	More	0	27	12	More	0	27	0	27	0	27	0	27	0	27	0	27	0	27	0	27	0	27	0	27	0
			28	0	28	0	More	0	28	12	More	0	28	0	28	0	28	0	28	0	28	0	28	0	28	0	28	0	28	0	28	0
			29	0	29	0	More	0	29	12	More	0	29	0	29	0	29	0	29	0	29	0	29	0	29	0	29	0	29	0	29	0
			30	0	30	0	More	0	30	12	More	0	30	0	30	0	30	0	30	0	30	0	30	0	30	0	30	0	30	0	30	0
			More	U	More	U	More	U	More	U	More	U	More	U	More	U	More	U	More	U	More	U	More	U	More	U	More	U	More	U	More	U

Table B-3. Simulation Results (cont)

Run #	SYSTEM	Start Area	Days	Loc Time	Rego Time	Stop Rules	Stop Time	Shrink %	Expand Rules	8-PT Time	5-PT Time	Expand %																				
73	B	800	8	2	2	24	50%	1.5	1	1	200%																					
EvTC	Bin	#	Tev	Bin	#	FASz	Bin	#	RedT	Bin	#	RndT(C)	Bin	#	Rnd(C)	Bin	#	MSR	Bin	#	A/Avg(NT)	Bin	#	MSR	Bin	#	A/Avg(NT(C))	Bin	#	MSR	Bin	#
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1	0	1	0	0	0	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	2	0	0	0	95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	3	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	4	0	0	0	127	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	5	0	0	0	169	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	6	0	0	0	200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	1	7	0	0	0	225	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	7	8	0	0	0	254	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	17	9	2	300	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	22	10	9	338	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	21	11	26	400	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	16	12	42	450	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	17	13	47	500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	12	14	51	800	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	15	10	900	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	16	3	1200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	17	0	1600	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	18	0	More	U	More	U	More	U	18	5	18	1	18	U	18	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	19	0	More	U	More	U	More	U	19	5	19	4	19	U	19	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	20	0	More	U	More	U	More	U	20	3	20	3	20	U	20	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	U	21	U	More	U	More	U	More	U	21	U	More	3	21	U	21	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	22	0	More	U	More	U	More	U	22	0	22	0	22	U	22	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	23	0	More	U	More	U	More	U	23	0	23	0	23	U	23	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	24	0	More	U	More	U	More	U	24	0	24	0	24	U	24	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	0	25	0	More	U	More	U	More	U	25	0	25	0	25	U	25	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	0	26	0	More	U	More	U	More	U	26	0	26	0	26	U	26	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	27	0	More	U	More	U	More	U	27	0	27	0	27	U	27	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	0	28	0	More	U	More	U	More	U	28	0	28	0	28	U	28	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	0	29	0	More	U	More	U	More	U	29	0	29	0	29	U	29	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	30	0	More	U	More	U	More	U	30	0	30	0	30	U	30	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
More	U	More	U	More	U	More	U	More	U	More	U	More	3	More	U	More	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Run #	SYSTEM	Start Area	Days	Loc Time	Rego Time	Stop Rules	Stop Time	Shrink %	Expand Rules	8-PT Time	5-PT Time	Expand %														
74	B	800	8	2	2	24	25%	1.5	1	1	200%															
EvTC	Bin	#	Tev	Bin	#	FASz	Bin	#	RedT	Bin	#	MSR	Bin	#	A/Avg(NT)	Bin	#	MSR	Bin	#	A/Avg(NT(C))	Bin	#	MSR	Bin	#
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	1	0	1	0	0	50	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	2	0	2	0	0	95	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	3	0	3	0	0	100	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	4	0	4	0	0	127	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	5	0	5	0	0	169	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	6	2	6	0	0	200	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	7	7	7	0	0	225	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	8	13	6	1	254	0	8	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	9	19	9	2	300	0	9	1	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	10	24	10	16	338	0	10	5	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	11	15	11	30	400	0	11	9	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	12	11	12	29	450	15	12	6	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	13	5	13	15	600	39	13	9	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	14	3	14	3	800	46	14	9	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	15	0	15	2	900	0	15	11	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	16	1	16	2	1000	0	16	13	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	17	0	17	0	1200	0	17	11	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	18	0	18	0	1600	0	18	4	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	19	0	19	0	More	0	19	6	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	20	0	20	0	More	0	20	4	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	21	0	21	0	More	0	More	3	More	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	22	0	22	0	More	0	More	0	More	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	23	0	23	0	More	0	More	0	More	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	24	0	24	0	More	0	More	0	More	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	25	0	25	0	More	0	More	0	More	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	26	0	26	0	More	0	More	0	More	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	27	0	27	0	More	0	More	0	More	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	28	0	28	0	More	0	More	0	More	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	29	0	29	0	More	0	More	0	More	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	30	0	30	0	More	0	More	0	More	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	More	U	More	U	More	U	More	U	More	U	More	U	More	U	More	U	More	U	More	U	More	U	More	U	More	U

Table B-3. Simulation Results (cont)

Run #	SYSTEM	75 B	EYIC		Twr		FASz		RsdT		RsdT(C)		MsdSR		A/Avp(WT)		A/Avp(TC)		MSR		MSRC	
			#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin
1	Start Area	800	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
8	Days	8	1	0	1	0	50	0	1	0	1	0	10	0	10	0	10	0	20	0	20	
2	Loc Time	2	0	2	0	95	0	2	0	2	0	20	0	20	0	20	0	40	0	40	0	
2	Stop Rules	2	3	0	3	0	100	0	3	0	3	0	30	0	30	0	30	0	60	2	60	
20	Shrink %	50%	4	0	4	0	127	0	4	0	4	0	40	0	40	5	40	0	80	14	80	
	Stop Time		5	0	5	0	169	0	5	0	5	0	50	13	50	26	50	0	100	21	100	
1	Expand Rules	1	6	0	6	0	200	20	6	0	6	0	60	38	60	37	60	60	120	19	120	
1.5	6-PM Time	1.5	7	0	7	0	225	0	7	0	7	0	70	23	70	20	70	70	140	13	140	
200%	Expand %	200%	8	0	8	0	254	0	8	0	8	0	80	15	80	7	80	80	160	16	160	
	9		5	9	0	300	0	9	2	6	1	90	12	90	5	90	5	180	8	180		
1		1	10	17	10	0	338	0	10	2	10	5	100	8	100	2	100	10	200	5	200	
1		1	11	21	11	6	400	65	11	5	11	11	110	0	110	0	110	110	220	3	220	
1		1	12	27	12	14	450	0	12	8	12	13	120	0	120	0	120	120	240	0	240	
1		1	13	12	13	25	600	0	13	12	13	20	130	1	130	0	130	130	260	1	260	
1		1	14	12	14	22	800	15	13	13	14	140	0	140	0	140	0	280	0	280		
1		1	15	3	15	11	900	0	15	21	15	17	150	1	150	0	150	150	300	3	300	
1		1	16	2	16	6	1200	0	16	9	16	0	160	0	160	0	160	160	320	0	320	
1		1	17	0	17	6	1800	0	17	9	17	3	170	0	170	0	170	170	340	1	340	
1		1	18	1	18	1	More	0	18	11	18	5	180	0	180	0	180	180	360	1	360	
1		1	19	0	19	1	More	0	19	3	19	2	190	0	190	0	190	190	380	1	380	
1		1	20	0	20	0	More	0	20	3	20	1	200	0	200	0	200	200	400	0	400	
1		1	21	0	21	1	More	0	21	0	21	0	210	0	210	0	210	210	420	0	420	
1		1	22	0	22	0	More	0	22	0	22	0	220	0	220	0	220	220	440	0	440	
1		1	23	0	23	0	More	0	23	0	23	0	230	0	230	0	230	230	460	0	460	
1		1	24	0	24	0	More	0	24	0	24	0	240	0	240	0	240	240	480	0	480	
1		1	25	0	25	0	More	0	25	0	25	0	250	0	250	0	250	250	500	0	500	
1		1	26	0	26	0	More	0	26	0	26	0	260	0	260	0	260	260	520	0	520	
1		1	27	0	27	0	More	0	27	0	27	0	270	0	270	0	270	270	540	0	540	
1		1	28	0	28	0	More	0	28	0	28	0	280	0	280	0	280	280	560	0	560	
1		1	29	0	29	0	More	0	29	0	29	0	290	0	290	0	290	290	580	0	580	
1		1	30	0	30	0	More	0	30	0	30	0	300	0	300	0	300	300	600	0	600	
1		1	More	U	More	U	More	0	More	0	More	0	310	U	310	U	310	310	620	U	620	
1		1	More	U	More	U	More	0	More	0	More	0	320	U	320	U	320	320	640	U	640	
1		1	More	U	More	U	More	0	More	0	More	0	330	U	330	U	330	330	660	U	660	
1		1	More	U	More	U	More	0	More	0	More	0	340	U	340	U	340	340	680	U	680	
1		1	More	U	More	U	More	0	More	0	More	0	350	U	350	U	350	350	700	U	700	
1		1	More	U	More	U	More	0	More	0	More	0	More	U	More	U	More	More	More	1	More	

76	Run #	EVTc		Tev		FASz		RsdT		RsdT(C)		MdsR		A/Avg(MT)		A/Avg(RT(C))		MSR		MSR(C)	
		Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#
SYSTEM	800	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Start Area	8	1	0	1	0	50	0	1	0	1	0	10	0	10	0	20	0	40	0	20	0
Days	2	2	0	2	0	95	0	2	0	2	0	20	0	30	1	30	0	60	1	40	0
Loc Time	2	3	0	3	0	100	0	3	0	3	0	30	1	30	1	40	0	80	14	60	0
Rego Rules	2	4	0	4	0	127	0	4	0	4	0	40	5	40	7	40	0	80	14	80	0
Stop Rules	20	5	0	5	0	169	0	5	0	5	0	50	9	50	22	50	16	100	16	100	0
Stop Time	25%	6	0	6	0	200	0	6	0	6	0	60	25	60	35	60	120	120	20	120	0
Shrink %	1.3	7	1	7	0	225	0	7	0	7	0	70	19	70	24	70	140	140	17	140	0
Expand Rules	1	8	11	8	1	254	1	8	0	8	1	80	19	80	35	80	160	160	15	160	0
8-PM Time	200%	9	14	9	0	300	0	9	1	9	1	90	11	90	4	90	180	180	4	180	0
Expand %	1	10	28	10	0	338	10	10	1	10	8	100	6	100	1	100	200	200	3	200	0
		11	21	11	12	400	0	11	7	11	15	110	2	110	0	110	220	220	3	220	0
		12	20	12	33	450	30	12	13	12	19	120	1	120	0	120	240	240	1	240	0
		13	3	13	26	600	44	13	10	13	20	130	0	130	0	130	260	260	0	260	0
		14	2	14	19	800	15	14	13	14	14	140	2	140	0	140	280	280	1	280	0
		15	0	15	7	900	0	15	11	15	14	150	0	150	0	150	300	300	0	300	0
		16	0	16	2	1200	0	16	14	16	7	160	0	160	0	160	320	320	2	320	0
		17	0	17	8	1600	0	17	8	17	3	170	0	170	0	170	340	340	1	340	0
		18	0	18	18	More	0	18	8	18	2	180	0	180	0	180	360	360	1	360	0
		19	0	19	0	More	0	19	4	19	0	190	0	190	0	190	380	380	0	380	0
		20	0	20	0	More	0	20	2	20	0	200	0	200	0	200	400	400	0	400	0
		21	0	21	0	More	8	21	0	21	0	210	0	210	0	210	420	420	1	420	0
		22	0	22	0	More	0	22	0	22	0	220	0	220	0	220	440	440	0	440	0
		23	0	23	0	More	0	23	0	23	0	230	0	230	0	230	460	460	0	460	0
		24	0	24	0	More	0	24	0	24	0	240	0	240	0	240	480	480	0	480	0
		25	0	25	0	More	0	25	0	25	0	250	0	250	0	250	500	500	0	500	0
		26	0	26	0	More	0	26	0	26	0	260	0	260	0	260	520	520	0	520	0
		27	0	27	0	More	0	27	0	27	0	270	0	270	0	270	540	540	0	540	0
		28	0	28	0	More	0	28	0	28	0	280	0	280	0	280	560	560	0	560	0
		29	0	29	0	More	0	29	0	29	0	290	0	290	0	290	580	580	0	580	0
		30	0	30	0	More	0	30	0	30	0	300	0	300	0	300	600	600	0	600	0
		More	0	More	0	More	0	More	0	More	0	310	0	310	0	310	620	620	0	620	0
												320	0	320	0	320	640	640	0	640	0
												330	0	330	0	330	660	660	0	660	0
												340	0	340	0	340	680	680	0	680	0
												350	0	350	0	350	700	700	0	700	0
												More	0	More	0	More	1	More	1	More	0

Table B-3. Simulation Results (cont)

Run #	SYSTEM	Start Area	Days	Loc Time	Repo Time	Stop Rules	Shrink %	Expand Rules	6-Pr Time	5-Pr Time	Expand %									
77	B	800	2	2	2	16	50%	1.5	1	200%										
EvTC	Bin	#	Tev	#	FASz	#	RndT	#	RndT(C)	#	MSR	#	A/Avg(NT)	Bin	#	MSR	#	A/Avg(NT(C))	Bin	#
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	1	0	0	50	0	0	0	1	0	0	0	10	0	20	0	20	0	20	0
2	0	2	0	0	95	0	2	0	2	0	0	0	20	0	40	0	40	0	40	0
3	0	3	0	0	137	0	3	0	3	0	0	0	30	0	60	1	60	0	60	0
4	0	4	0	0	177	0	4	0	4	0	0	0	40	0	80	14	80	0	80	14
5	0	5	0	0	169	0	5	0	5	0	0	0	50	10	100	26	100	26	100	25
6	0	6	0	0	205	59	6	0	6	0	0	0	60	29	60	42	60	31	120	17
7	0	7	0	0	225	0	7	0	7	0	0	0	70	27	70	33	140	10	140	10
8	0	8	0	0	244	0	8	0	8	0	0	0	80	17	80	14	160	15	160	16
9	0	9	0	0	308	0	9	0	9	0	0	0	90	10	90	0	180	5	180	5
10	2	10	0	0	438	0	10	4	10	0	0	0	100	2	100	0	200	5	200	6
11	3	11	0	0	450	38	11	4	11	0	0	0	110	0	110	0	220	0	220	0
12	6	12	0	0	450	0	12	5	12	14	120	2	120	0	120	0	240	3	240	2
13	14	13	2	600	0	13	11	13	13	130	0	0	130	0	130	0	260	1	260	1
14	20	14	6	800	0	14	9	14	14	140	0	0	140	0	140	0	280	0	280	0
15	16	15	14	900	0	15	15	15	15	150	0	0	150	0	150	0	300	2	300	2
16	23	16	13	1200	0	16	15	16	16	160	0	0	160	0	160	0	320	0	320	0
17	11	17	10	1500	0	17	6	17	6	170	0	0	170	0	170	0	340	1	340	1
18	1	18	10	More	More	18	12	18	18	180	0	0	180	0	180	0	360	0	360	0
19	1	19	20	More	More	19	4	19	0	190	0	0	190	0	190	0	380	0	380	0
20	0	20	10	More	More	20	5	20	0	200	0	0	200	0	200	0	400	0	400	0
21	0	21	0	More	More	21	0	21	0	210	0	0	210	0	210	0	420	0	420	0
22	0	22	1	More	More	22	0	22	0	220	0	0	220	0	220	0	440	0	440	0
23	0	23	0	More	More	23	0	23	0	230	0	0	230	0	230	0	460	0	460	0
24	0	24	0	More	More	24	0	24	0	240	0	0	240	0	240	0	480	0	480	0
25	0	25	0	More	More	25	0	25	0	250	0	0	250	0	250	0	500	0	500	0
26	0	26	0	More	More	26	0	26	0	260	0	0	260	0	260	0	520	0	520	0
27	0	27	0	More	More	27	0	27	0	270	0	0	270	0	270	0	540	0	540	0
28	0	28	0	More	More	28	0	28	0	280	0	0	280	0	280	0	560	0	560	0
29	0	29	0	More	More	29	0	29	0	290	0	0	290	0	290	0	580	0	580	0
30	0	30	0	More	More	30	0	30	0	300	0	0	300	0	300	0	600	0	600	0
More	U	More	U	More	More	More	U	More	U	More	U	U	More	U	More	U	620	U	620	U
						</														

Run #	SYSTEM	Start Area	Days	Loc Time	Repo Time	Stop Rules	Shrink %	Expand Rules	6-Pr Time	5-Pr Time	Expand %									
78	B	800	2	2	2	16	25%	1.5	1	200%										
EvTC	Bin	#	Tev	#	FASz	#	RndT	#	RndT(C)	#	MSR	#	A/Avg(NT)	Bin	#	MSR	#	MSR(C)	Bin	#
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	1	0	0	90	0	1	0	1	0	10	0	10	0	0	20	0	20	0	0
2	0	2	0	0	95	0	2	0	2	0	20	0	20	0	0	40	0	40	0	0
3	0	3	0	0	100	0	3	0	3	0	30	0	30	0	0	60	3	60	1	1
4	0	4	0	0	127	0	4	0	4	0	40	0	40	0	0	80	15	80	15	15
5	0	5	0	0	127	0	5	0	5	0	50	9	50	6	27	100	23	100	21	21
6	0	6	0	0	169	0	6	0	6	0	60	32	60	35	120	160	120	160	16	16
7	1	7	0	0	200	0	7	0	7	0	70	25	70	16	10	140	12	140	15	15
8	1	8	0	0	225	0	8	0	8	0	80	12	80	10	10	160	10	160	10	10
9	7	9	0	0	254	8	9	0	9	2	90	11	90	9	15	180	10	180	11	11
10	18	10	0	0	308	32	10	2	10	14	100	6	100	0	100	3	200	3	200	3
11	28	11	0	0	400	0	11	7	11	15	110	0	110	0	110	2	220	2	220	2
12	12	12	6	450	41	12	6	12	23	120	120	2	120	0	120	0	240	0	240	0
13	15	13	11	600	17	13	5	13	19	130	130	0	130	0	130	0	260	1	260	0
14	7	14	28	800	2	14	18	14	15	140	150	0	140	0	140	0	280	0	280	0
15	0	15	28	900	0	15	12	15	10	150	160	0	150	0	150	0	300	3	300	2
16	1	16	19	1200	0	16	12	16	1	160	170	0	160	0	160	0	320	0	320	1
17	0	17	4	1600	0	17	14	17	0	170	180	0	170	0	170	0	340	1	340	0
18	0	18	4	More	0	18	5	18	0	180	190	0	180	0	180	0	360	1	360	1
19	0	19	0	More	0	19	8	19	0	190	200	0	190	0	190	0	380	0	380	0
20	0	20	0	20	0	20	0	20	0	200	210	0	200	0	200	0	400	0	400	0
21	0	21	0	21	0	21	10	21	More	210	220	0	210	0	210	0	420	0	420	0
22	0	22	0	22	0	22	10	22	More	220	230	0	220	0	220	0	440	0	440	0
23	0	23	0	23	0	23	10	23	More	230	240	0	230	0	230	0	460	0	460	0
24	0	24	0	24	0	24	10	24	More	240	250	0	240	0	240	0	480	0	480	0
25	0	25	0	25	0	25	10	25	More	250	260	0	250	0	250	0	500	0	500	0
26	0	26	0	26	0	26	10	26	More	260	270	0	260	0	260	0	520	0	520	0
27	0	27	0	27	0	27	10	27	More	270	280	0	270	0	270	0	540	0	540	0
28	0	28	0	28	0	28	10	28	More	280	290	0	280	0	280	0	560	0	560	0
29	0	29	0	29	0	29	10	29	More	290	300	0	290	0	290	0	580	0	580	0
30	0	30	0	30	0	30	10	30	More	300	310	0	300	0	300	0	600	0	600	0
More	U	More	U	More	U	More	U	More	U	310	320	0	310	0	310	0	620	0	620	0
										320	330	0	320	0	320	0	640	0	640	0
										330	340	0	330	0	330	0	660	0	660	0
										340	350	0	340	0	340	0	680	0	680	0
										350	350	0	350	0	350	0	700	0	700	0
										More	More	0	More	0	More	0	700	1	More	More

Table B-3. Simulation Results (cont)

Run #	SYSTEM	Start Area	Days	Loc Time	Rego Time	Stop Rules	Stop Time	Shrink %	Expand Rules	6-PT Time	Expand %
79	B	800	8	2	2	12	50%	1.5	1	200%	
Bin	#	EW	FASZ	RedT	RedT(C)	MdSR	A/Avg(NT)	MSR	MSR(C)	#	Bin
0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0
More	U	More	U	More	U	More	U	More	U	More	U

Table B-3. Simulation Results (cont)

Run #	SYSTEM	Start Area	Days	Loc Time	Rego Time	Stop Rules	Shrink %	Expand Rules	6-Pt Time	5-Pt Time	Expand %	EvTC	Tev	FASz	RndT	#	RndT(C)	#	MSR	#	A/Avg(RT)	Bin	MSR	#	A/Avg(RT(C))	Bin	MSR	#	MSR(C)	Bin	#
												Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin
81	B	800	8	4	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
82	B	800	8	4	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	B	800	8	4	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	B	800	8	4	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.5	B	800	8	4	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	B	800	8	4	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
200%	B	800	8	4	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table B-3. Simulation Results (cont)

Run #	SYSTEM	Start Area	Days	Loc Time	Rego Time	Stop Rules	Shrink %	Expand Rules	6-PT Time	5-PT Time	Expand %
83	B	800	8	4	2	20	50%	1.5	1	200%	
EvTC	#	Tev	FASz	RndT	RndT(C)	MSR	A/Avg(NT)	A/Avg(NT(C))	MSR	MSR(C)	#
Bin		Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin	Bin
0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0
More	0	0	0	0	0	0	0	0	0	0	0

Table B-3. Simulation Results (cont)

Run #	SYSTEM	BS	EvTC		Twv	FASz		RedT	RedT(C)		MidSR	AAvg(WT)		AAvg(NTC)	MSR		MSR(C)	
			#	Bin		#	Bin		#	Bin		#	Bin		#	Bin		
1	806	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2	8	4	2	0	0	50	0	1	0	0	10	0	10	0	20	0	20	
3	2	0	0	0	0	100	0	2	0	2	20	0	20	0	40	0	40	
4	0	0	0	0	0	120	0	4	0	4	30	0	30	0	60	2	60	
5	0	0	0	0	0	160	0	5	0	5	40	0	40	0	80	16	80	
6	30%	16	5	0	5	0	50	0	5	0	50	33	50	17	100	14	100	
7	0	7	0	0	0	200	43	6	0	6	60	23	60	34	120	25	120	
8	0	7	0	0	0	225	0	7	0	7	70	22	70	16	140	8	140	
9	1.5	2	0	0	0	254	0	8	1	8	80	24	80	6	160	13	160	
10	200%	10	0	0	0	308	0	9	1	9	90	3	90	5	180	5	180	
11	14	10	0	0	0	338	0	10	3	10	100	6	100	3	200	6	200	
12	31	12	8	4	54	11	4	11	11	11	110	1	110	0	220	3	220	
13	19	13	24	600	0	13	14	13	15	120	0	120	1	120	1	240	1	240
14	7	14	25	800	2	14	9	14	14	140	0	140	0	140	0	280	0	280
15	2	15	25	900	0	15	11	15	16	150	1	150	0	150	0	300	1	300
16	0	16	2	1200	0	16	16	16	16	160	0	160	0	160	0	320	2	320
17	0	17	2	1600	0	17	10	17	17	170	0	170	0	170	0	340	1	340
18	0	18	2	More	U	18	14	18	14	180	U	180	U	180	U	360	U	360
19	0	19	0	More	U	19	6	19	2	190	0	190	0	190	0	380	0	380
20	0	20	0	20	0	20	3	20	0	200	0	200	0	200	0	400	0	400
21	0	21	U	21	U	21	4	More	U	210	U	210	U	210	U	420	U	420
22	0	22	0	22	0	22	0	220	0	220	0	220	0	220	0	440	0	440
23	0	23	0	23	0	23	0	230	0	230	0	230	0	230	0	460	0	460
24	0	24	0	24	0	24	0	240	0	240	0	240	0	240	0	480	0	480
25	0	25	0	25	0	25	0	250	0	250	0	250	0	250	0	500	0	500
26	0	26	0	26	0	26	0	260	0	260	0	260	0	260	0	520	0	520
27	0	27	0	27	0	27	0	270	0	270	0	270	0	270	0	540	0	540
28	0	28	0	28	0	28	0	280	0	280	0	280	0	280	0	560	0	560
29	0	29	0	29	0	29	0	290	0	290	0	290	0	290	0	580	0	580
30	0	30	0	30	0	30	0	300	0	300	0	300	0	300	0	600	0	600
More	U	More	U	More	U	More	U	310	U	310	U	310	U	310	U	620	U	620
								320	0	320	0	320	0	320	0	640	0	640
								330	0	330	0	330	0	330	0	660	0	660
								340	0	340	0	340	0	340	0	680	0	680
								350	0	350	0	350	0	350	0	700	0	700
								More	U	More	U	More	U	More	U	More	U	More

Run #	EVC		Tev		FASz		RndT		Rnd(C)		MSR		A/Avg(MT)		A/Avg(MT(C))		MSR		MSR(C)	
	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin
86	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SYSTEM	1	0	1	0	0	50	0	1	0	10	0	10	0	10	0	10	0	20	0	20
Start Area	8	1	0	1	0	95	0	2	0	20	0	20	0	20	0	20	0	40	0	40
Days	4	2	0	2	0	100	0	3	0	30	0	30	0	30	0	30	0	60	5	60
Loc Time	2	3	0	3	0	127	0	4	0	40	0	40	0	40	0	40	0	13	0	13
Rep Rules	2	4	0	4	0	169	0	5	0	5	0	50	0	50	0	50	0	100	21	100
Stop Time	18	5	0	5	0	200	0	6	0	6	0	60	0	60	0	60	0	18	120	18
Shrink %	25%	6	0	6	0	225	0	7	1	7	0	70	0	70	0	70	0	35	140	15
Expand Rules	1	7	4	7	0	254	4	8	0	8	2	80	0	80	0	80	0	28	160	10
8-PN Time	1.5	8	9	8	0	300	0	9	0	9	15	90	3	90	15	90	3	180	7	180
8-PN Time	1	9	33	9	0	338	27	10	3	10	15	100	4	100	0	100	4	200	2	200
Expand %	200%	10	29	10	1	400	0	11	10	11	17	110	2	110	0	110	2	220	0	220
		11	19	11	7	450	47	12	7	12	16	120	1	120	0	120	1	240	2	240
		12	4	12	24	600	18	13	10	13	23	130	1	130	0	130	1	260	1	260
		13	1	13	43	800	4	14	6	14	8	140	0	140	0	140	0	280	1	280
		14	1	14	21	900	0	15	13	15	14	150	0	150	0	150	0	300	1	300
		15	0	15	3	1200	0	16	8	16	1	160	1	160	0	160	0	320	0	320
		16	0	16	1	1600	0	17	13	17	1	170	0	170	0	170	0	340	0	340
		17	0	17	0	More	0	18	8	18	0	180	0	180	0	180	0	360	0	360
		18	0	18	0	More	0	19	7	19	0	190	0	190	0	190	0	380	1	380
		19	0	19	0	More	0	20	4	20	0	200	0	200	0	200	0	400	0	400
		20	0	20	0	More	0	21	8	More	0	210	0	210	0	210	0	420	0	420
		21	0	21	0	More	0	22	0	More	0	220	0	220	0	220	0	440	0	440
		22	0	22	0	More	0	23	0	More	0	230	0	230	0	230	0	460	0	460
		23	0	23	0	More	0	24	0	More	0	240	0	240	0	240	0	480	0	480
		24	0	24	0	More	0	25	0	More	0	250	0	250	0	250	0	500	0	500
		25	0	25	0	More	0	26	0	More	0	260	0	260	0	260	0	520	0	520
		26	0	26	0	More	0	27	0	More	0	270	0	270	0	270	0	540	0	540
		27	0	27	0	More	0	28	0	More	0	280	0	280	0	280	0	560	0	560
		28	0	28	0	More	0	29	0	More	0	290	0	290	0	290	0	580	0	580
		29	0	29	0	More	0	30	0	More	0	300	0	300	0	300	0	600	0	600
		30	0	30	0	More	0	31	0	More	0	310	0	310	0	310	0	620	0	620
		More	0	More	0	More	0	32	0	More	0	320	0	320	0	320	0	640	0	640
		More	0	More	0	More	0	33	0	More	0	330	0	330	0	330	0	660	0	660
		More	0	More	0	More	0	34	0	More	0	340	0	340	0	340	0	680	0	680
		More	0	More	0	More	0	35	0	More	0	350	0	350	0	350	0	700	0	700
		More	0	More	0	More	0	More	0	More	0	More	0	More	0	More	0	More	1	More

Table B-3. Simulation Results (cont)

Run #	SYSTEM	Start Area	Days	Loc Time	Regio Time	Stop Rules	Stop Time	Shrink %	Expand Rules	Expand Time	Expand %
87	B	800	1	0	0	0	0	0	0	0	0
88	B	800	1	0	0	0	0	0	0	0	0
89	B	800	1	0	0	0	0	0	0	0	0
90	B	800	1	0	0	0	0	0	0	0	0
91	B	800	1	0	0	0	0	0	0	0	0
92	B	800	1	0	0	0	0	0	0	0	0
93	B	800	1	0	0	0	0	0	0	0	0
94	B	800	1	0	0	0	0	0	0	0	0
95	B	800	1	0	0	0	0	0	0	0	0
96	B	800	1	0	0	0	0	0	0	0	0
97	B	800	1	0	0	0	0	0	0	0	0
98	B	800	1	0	0	0	0	0	0	0	0
99	B	800	1	0	0	0	0	0	0	0	0
100	B	800	1	0	0	0	0	0	0	0	0
101	B	800	1	0	0	0	0	0	0	0	0
102	B	800	1	0	0	0	0	0	0	0	0
103	B	800	1	0	0	0	0	0	0	0	0
104	B	800	1	0	0	0	0	0	0	0	0
105	B	800	1	0	0	0	0	0	0	0	0
106	B	800	1	0	0	0	0	0	0	0	0
107	B	800	1	0	0	0	0	0	0	0	0
108	B	800	1	0	0	0	0	0	0	0	0
109	B	800	1	0	0	0	0	0	0	0	0
110	B	800	1	0	0	0	0	0	0	0	0
111	B	800	1	0	0	0	0	0	0	0	0
112	B	800	1	0	0	0	0	0	0	0	0
113	B	800	1	0	0	0	0	0	0	0	0
114	B	800	1	0	0	0	0	0	0	0	0
115	B	800	1	0	0	0	0	0	0	0	0
116	B	800	1	0	0	0	0	0	0	0	0
117	B	800	1	0	0	0	0	0	0	0	0
118	B	800	1	0	0	0	0	0	0	0	0
119	B	800	1	0	0	0	0	0	0	0	0
120	B	800	1	0	0	0	0	0	0	0	0
121	B	800	1	0	0	0	0	0	0	0	0
122	B	800	1	0	0	0	0	0	0	0	0
123	B	800	1	0	0	0	0	0	0	0	0
124	B	800	1	0	0	0	0	0	0	0	0
125	B	800	1	0	0	0	0	0	0	0	0
126	B	800	1	0	0	0	0	0	0	0	0
127	B	800	1	0	0	0	0	0	0	0	0
128	B	800	1	0	0	0	0	0	0	0	0
129	B	800	1	0	0	0	0	0	0	0	0
130	B	800	1	0	0	0	0	0	0	0	0
131	B	800	1	0	0	0	0	0	0	0	0
132	B	800	1	0	0	0	0	0	0	0	0
133	B	800	1	0	0	0	0	0	0	0	0
134	B	800	1	0	0	0	0	0	0	0	0
135	B	800	1	0	0	0	0	0	0	0	0
136	B	800	1	0	0	0	0	0	0	0	0
137	B	800	1	0	0	0	0	0	0	0	0
138	B	800	1	0	0	0	0	0	0	0	0
139	B	800	1	0	0	0	0	0	0	0	0
140	B	800	1	0	0	0	0	0	0	0	0
141	B	800	1	0	0	0	0	0	0	0	0
142	B	800	1	0	0	0	0	0	0	0	0
143	B	800	1	0	0	0	0	0	0	0	0
144	B	800	1	0	0	0	0	0	0	0	0
145	B	800	1	0	0	0	0	0	0	0	0
146	B	800	1	0	0	0	0	0	0	0	0
147	B	800	1	0	0	0	0	0	0	0	0
148	B	800	1	0	0	0	0	0	0	0	0
149	B	800	1	0	0	0	0	0	0	0	0
150	B	800	1	0	0	0	0	0	0	0	0
151	B	800	1	0	0	0	0	0	0	0	0
152	B	800	1	0	0	0	0	0	0	0	0
153	B	800	1	0	0	0	0	0	0	0	0
154	B	800	1	0	0	0	0	0	0	0	0
155	B	800	1	0	0	0	0	0	0	0	0
156	B	800	1	0	0	0	0	0	0	0	0
157	B	800	1	0	0	0	0	0	0	0	0
158	B	800	1	0	0	0	0	0	0	0	0
159	B	800	1	0	0	0	0	0	0	0	0
160	B	800	1	0	0	0	0	0	0	0	0
161	B	800	1	0	0	0	0	0	0	0	0
162	B	800	1	0	0	0	0	0	0	0	0
163	B	800	1	0	0	0	0	0	0	0	0
164	B	800	1	0	0	0	0	0	0	0	0
165	B	800	1	0	0	0	0	0	0	0	0
166	B	800	1	0	0	0	0	0	0	0	0
167	B	800	1	0	0	0	0	0	0	0	0
168	B	800	1	0	0	0	0	0	0	0	0
169	B	800	1	0	0	0	0	0	0	0	0
170	B	800	1	0	0	0	0	0	0	0	0
171	B	800	1	0	0	0	0	0	0	0	0
172	B	800	1	0	0	0	0	0	0	0	0
173	B	800	1	0	0	0	0	0	0	0	0
174	B	800	1	0	0	0	0	0	0	0	0
175	B	800	1	0	0	0	0	0	0	0	0
176	B	800	1	0	0	0	0	0	0	0	0
177	B	800	1	0	0	0	0	0	0	0	0
178	B	800	1	0	0	0	0	0	0	0	0
179	B	800	1	0	0	0	0	0	0	0	0
180	B	800	1	0	0	0	0	0	0	0	0
181	B	800	1	0	0	0	0	0	0	0	0
182	B	800	1	0	0	0	0	0	0	0	0
183	B	800	1	0	0	0	0	0	0	0	0
184	B	800	1	0	0	0	0	0	0	0	0
185	B	800	1	0	0	0	0	0	0	0	0
186	B	800	1	0	0	0	0	0	0	0	0
187	B	800	1	0	0	0	0	0	0	0	0
188	B	800	1	0	0	0	0	0	0	0	0
189	B	800	1	0	0	0	0	0	0	0	0
190	B	800	1	0	0	0	0	0	0	0	0
191	B	800	1	0	0	0	0	0	0	0	0
192	B	800	1	0	0	0	0	0	0	0	0
193	B	800	1	0	0	0	0	0	0	0	0
194	B	800	1	0	0	0	0	0	0	0	0
195	B	800	1	0	0	0	0	0	0	0	0
196	B	800	1	0	0	0	0	0	0	0	0
197	B	800	1	0	0	0	0	0	0	0	0
198	B	800	1	0	0	0	0	0	0	0	0
199	B	800	1	0	0	0	0	0	0	0	0
200	B	800	1	0	0	0	0	0	0	0	0

Table B-3. Simulation Results (cont)

Run #	SYSTEM	Start Area	Days	Loc Time	Repo Time	Stop Rules	Stop Time	Shrink %	Expand Rules	6-PI Time	5-PI Time	Expand %
89	B	800	8	2	3	4	5	6	7	8	9	10
1.5												
200%												
EvTC	#	Tev	FASr	RndT	#	RndT(C)	MSR	#	A/Avg(NT)	MSR	#	MSR(C)
Bin		Bin	Bin	Bin		Bin	Bin		Bin	Bin		Bin
0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	1	0	0	0	0	0	0	0	0	0	0
2	0	2	0	0	0	0	0	0	0	0	0	0
3	0	3	0	0	0	0	0	0	0	0	0	0
4	0	4	0	0	0	0	0	0	0	0	0	0
5	1	5	0	0	0	0	0	0	0	0	0	0
6	18	6	0	0	0	0	0	0	0	0	0	0
7	29	7	4	225	0	7	1	70	24	70	18	14
8	37	8	38	254	0	8	0	80	22	80	15	9
9	11	9	38	300	0	9	3	90	11	90	3	3
10	3	10	17	338	0	10	2	100	10	100	4	4
11	11	11	3	400	35	11	8	110	4	110	2	2
12	0	12	0	450	0	12	16	120	3	120	3	3
13	0	13	0	600	0	13	8	130	1	130	0	0
14	0	14	0	800	64	14	9	140	0	140	0	0
15	0	15	0	900	0	15	13	150	1	150	0	0
16	0	16	0	1200	0	16	10	160	0	160	0	0
17	0	17	0	1600	0	17	9	170	0	170	0	0
18	0	18	0	More	0	18	1	180	0	180	0	0
19	0	19	0	More	0	19	2	190	0	190	0	0
20	0	20	0	More	0	20	2	200	0	200	0	0
21	0	21	0	More	0	21	2	210	0	210	0	0
22	0	22	0	More	0	22	0	220	0	220	0	0
23	0	23	0	More	0	23	0	230	0	230	0	0
24	0	24	0	More	0	24	0	240	0	240	0	0
25	0	25	0	More	0	25	0	250	0	250	0	0
26	0	26	0	More	0	26	0	260	0	260	0	0
27	0	27	0	More	0	27	0	270	0	270	0	0
28	0	28	0	More	0	28	0	280	0	280	0	0
29	0	29	0	More	0	29	0	290	0	290	0	0
30	0	30	0	More	0	30	0	300	0	300	0	0
More	0	More	0	More	0	More	0	More	0	More	0	More

Run #	SYSTEM	Start Area	Days	Loc Time	Repo Time	Stop Rules	Stop Time	Shrink %	Expand Rules	6-PI Time	5-PI Time	Expand %
90	B	800	8	2	3	4	5	6	7	8	9	10
1.5												
200%												
EvTC	#	Tev	FASr	RndT	#	RndT(C)	MSR	#	A/Avg(NT)	MSR	#	MSR(C)
Bin		Bin	Bin	Bin		Bin	Bin		Bin	Bin		Bin
0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	1	0	0	0	0	0	0	0	0	0	0
2	0	2	0	0	0	0	0	0	0	0	0	0
3	0	3	0	0	0	0	0	0	0	0	0	0
4	2	4	0	0	0	0	0	0	0	0	0	0
5	10	5	0	0	0	0	0	0	0	0	0	0
6	16	6	0	0	0	0	0	0	0	0	0	0
7	28	7	8	225	0	7	1	70	21	70	16	15
8	30	8	41	254	0	8	0	80	14	80	5	6
9	11	9	44	300	0	9	3	90	10	90	6	6
10	2	10	6	338	0	10	4	100	5	100	2	2
11	1	11	1	400	7	11	11	110	6	110	4	4
12	0	12	0	450	0	12	5	120	0	120	0	0
13	0	13	0	600	23	13	14	130	4	130	0	0
14	0	14	0	800	60	14	10	140	1	140	0	0
15	0	15	0	900	0	15	12	150	0	150	0	0
16	0	16	0	1200	0	16	7	160	0	160	0	0
17	0	17	0	1600	0	17	11	170	0	170	0	0
18	0	18	0	More	0	18	4	180	0	180	0	0
19	0	19	0	More	0	19	1	190	0	190	0	0
20	0	20	0	More	0	20	2	200	0	200	0	0
21	0	21	0	More	0	21	0	210	0	210	0	0
22	0	22	0	More	0	22	0	220	0	220	0	0
23	0	23	0	More	0	23	0	230	0	230	0	0
24	0	24	0	More	0	24	0	240	0	240	0	0
25	0	25	0	More	0	25	0	250	0	250	0	0
26	0	26	0	More	0	26	0	260	0	260	0	0
27	0	27	0	More	0	27	0	270	0	270	0	0
28	0	28	0	More	0	28	0	280	0	280	0	0
29	0	29	0	More	0	29	0	290	0	290	0	0
30	0	30	0	More	0	30	0	300	0	300	0	0
More	0	More	0	More	0	More	0	More	0	More	0	More

Table B-3. Simulation Results (cont)

Run #	E7C		Tew		FASZ		RedT		RedT(C)		MidSR		A/Vavg(N/T)		A/Vavg(N/C)		MSR		MSR(C)	
	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin
SYSTEM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Start Area	1	0	1	0	0	0	1	0	1	0	10	0	10	0	10	0	20	0	20	0
Days	8	0	2	0	0	95	0	2	0	2	0	20	0	40	0	40	0	40	0	0
Rep. Rate	3	0	3	0	0	100	0	3	0	3	0	30	0	30	0	60	0	60	0	0
Stop Rules	2	4	0	4	0	127	0	4	0	4	0	40	0	40	0	80	0	16	0	15
Stop Time	20	5	0	5	0	169	0	5	0	5	0	50	0	50	0	100	0	21	0	21
Shrink %	50%	6	4	6	0	200	10	6	0	6	0	60	0	60	0	120	0	18	0	17
Expand Rules	1.5	7	27	7	0	225	0	7	1	7	1	70	0	70	0	140	0	20	0	20
5-PT Time	1	8	50	8	8	254	0	8	1	8	1	80	0	80	0	160	0	3	0	3
Expand %	200%	9	13	9	39	300	0	9	1	9	2	90	0	90	0	180	0	5	0	5
		10	4	10	36	338	0	10	5	10	11	100	0	100	0	200	0	2	0	2
		11	2	11	13	400	56	11	9	11	16	110	0	110	0	220	0	4	0	4
		12	0	12	3	450	0	12	9	12	18	120	0	120	0	240	0	2	0	2
		13	0	13	1	600	0	13	14	13	16	130	0	130	0	260	0	2	0	2
		14	0	14	0	800	34	14	8	14	10	140	0	140	0	280	0	2	0	2
		15	0	15	0	900	0	15	16	15	9	150	0	150	0	300	0	2	0	2
		16	0	16	0	1200	0	16	18	16	9	160	0	160	0	320	0	1	0	1
		17	0	17	0	1600	0	17	8	17	4	170	0	170	0	340	0	1	0	1
		18	0	18	0	More	0	18	4	18	1	180	0	180	0	360	0	1	0	1
		19	0	19	0	More	0	19	2	19	4	190	0	190	0	380	0	0	0	0
		20	0	20	0	More	0	20	6	20	2	200	0	200	0	400	0	0	0	0
		21	0	21	0	More	0	21	10	21	0	210	0	210	0	420	0	0	0	0
		22	0	22	0	More	0	22	0	22	0	220	0	220	0	440	0	0	0	0
		23	0	23	0	More	0	23	0	23	0	230	0	230	0	460	0	0	0	0
		24	0	24	0	More	0	24	0	24	0	240	0	240	0	480	0	0	0	0
		25	0	25	0	More	0	25	0	25	0	250	0	250	0	500	0	1	0	1
		26	0	26	0	More	0	26	0	26	0	260	0	260	0	520	0	1	0	1
		27	0	27	0	More	0	27	0	27	0	270	0	270	0	540	0	0	0	0

Run #	SYSTEM	B	E-UTC	Tev		FASz		RadT		Rad(C)		MgSR	A/Avg(MT)		#	A/Avg(MT(C))		#	MSR		#	MSR(C)		#
				#	Bin	#	Bin	#	Bin	#	Bin		#	Bin		#	Bin		#	Bin		#	Bin	
92																								
1	Start Area	800	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	Drift Area	8	1	0	1	0	50	0	1	0	1	0	10	10	0	10	10	20	0	20	0	20	0	0
3	Loc Time	8	2	0	2	0	95	0	2	0	2	0	20	20	0	20	20	40	0	40	0	40	0	0
4	Stop Rules	2	3	0	3	0	100	0	3	0	3	0	30	30	0	30	30	60	2	60	1	60	1	1
5	Stop Rules	4	4	0	4	0	127	0	4	0	4	0	40	40	3	40	40	80	16	80	16	80	16	16
6	Stop Rules	5	3	5	0	0	169	0	5	0	5	0	50	50	11	50	50	100	19	100	19	100	19	19
7	Stop Rules	25%	6	14	6	0	200	0	6	1	6	1	60	21	60	35	70	120	24	120	24	120	24	24
8	Stop Rules	1	7	42	7	0	225	0	7	0	7	0	70	22	70	17	80	140	13	140	15	140	15	15
9	Expand Rules	1.5	8	32	8	9	254	0	8	0	8	0	80	21	80	13	90	160	8	160	8	160	8	8
10	Expand Rules	1	9	6	9	49	300	0	9	2	9	4	90	8	90	2	100	180	3	180	3	180	3	3
11	Expand Rules	200%	10	2	10	39	338	5	10	2	10	4	100	6	100	2	110	200	4	200	4	200	4	4
12	Expand Rules		11	0	11	2	400	0	11	9	11	20	110	3	110	0	120	220	3	220	3	220	3	3
13	Expand Rules		12	1	12	1	450	19	12	6	12	14	120	3	120	0	130	240	1	240	1	240	1	1
14	Expand Rules		13	0	13	0	600	43	13	11	13	21	130	1	130	0	140	260	0	260	0	260	0	0
15	Expand Rules		14	0	14	0	800	33	14	6	14	20	140	0	140	0	150	280	0	280	0	280	0	0
16	Expand Rules		15	0	15	0	900	0	15	21	15	9	150	0	150	1	160	300	2	300	2	300	2	2
17	Expand Rules		16	0	16	0	1200	0	16	10	16	5	160	0	160	0	170	320	0	320	0	320	0	0
18	Expand Rules		17	0	17	0	1600	0	17	11	17	1	170	0	170	0	180	340	0	340	0	340	0	0
19	Expand Rules		18	0	18	0	More	U	18	3	18	1	180	U	180	U	190	360	U	360	U	360	U	U
20	Expand Rules		19	0	19	0	More	U	19	3	19	0	190	0	190	0	200	380	1	380	1	380	1	1
21	Expand Rules		20	0	20	0	More	U	20	4	20	0	200	1	200	0	210	400	0	400	0	400	0	0
22	Expand Rules		21	U	21	U	More	U	21	9	More	U	210	U	210	U								

Table B-3. Simulation Results (cont)

Table B-3. Simulation Results (cont)

Run #	SYSTEM	Start Area	Days	Loc Time	Rego Time	Stop Rules	Shrink %	Expand Rules	6-PI Time	5-PI Time	Expand %	EVT		Tev		FASZ		RndT		RndT(C)		MSR		A/Avg(NT)		A/Avg(NT(C))		MSR		MSR(C)		#		
												Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#	Bin	#		Bin	#
95												0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
800												1	0	1	0	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
8												2	0	2	0	95	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0		
2												3	0	3	0	100	6	3	0	3	0	0	0	0	0	0	0	0	0	0	0	0		
12												4	0	4	0	127	0	4	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	
50%												5	0	5	0	169	0	5	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	
12												6	0	6	0	200	72	6	0	6	0	1	60	23	60	33	120	20	120	20	120	20	21	
50%												7	0	7	0	225	0	7	0	7	0	1	70	25	70	19	140	12	140	12	140	12	14	
1.5												8	4	8	0	254	0	8	0	8	0	2	80	16	80	6	80	6	80	6	80	6	4	
200%												9	28	9	0	338	0	9	1	9	6	6	90	11	90	7	180	5	180	5	180	5	5	
1												10	50	10	0	400	0	10	6	10	13	100	3	100	0	100	0	100	0	100	0	100	0	1
												11	16	11	9	450	0	11	4	11	20	110	0	110	0	110	0	110	0	110	0	110	0	2
												12	2	12	31	450	0	12	6	12	17	120	2	120	0	120	0	120	0	120	0	120	0	2
												13	0	13	41	600	0	13	13	13	17	130	2	130	0	130	0	130	0	130	0	130	0	1
												14	0	14	17	800	1	14	9	14	9	140	0	140	0	140	0	140	0	140	0	140	0	0
												15	0	15	2	900	0	15	13	15	14	150	0	150	0	150	0	150	0	150	0	150	0	0
												16	0	16	0	1200	0	16	13	16	4	160	1	160	0	160	0	160	0	160	0	160	0	1
												17	0	17	0	1600	0	17	10	17	2	170	0	170	0	170	0	170	0	170	0	170	0	1
												18	0	18	0	More	0	18	7	18	0	180	0	180	0	180	0	180	0	180	0	180	0	0
												19	0	19	0	More	0	19	8	19	1	190	0	190	0	190	0	190	0	190	0	190	0	0
												20	0	20	0	More	0	20	2	20	0	200	0	200	0	200	0	200	0	200	0	200	0	0
												21	0	21	0	More	0	21	5	21	0	210	0	210	0	210	0	210	0	210	0	210	0	1
												22	0	22	0	More	0	22	5	22	0	220	0	220	0	220	0	220	0	220	0	220	0	0
												23	0	23	0	More	0	23	5	23	0	230	0	230	0	230	0	230	0	230	0	230	0	0
												24	0	24	0	More	0	24	5	24	0	240	0	240	0	240	0	240	0	240	0	240	0	0
												25	0	25	0	More	0	25	5	25	0	250	0	250	0	250	0	250	0	250	0	250	0	0
												26	0	26	0	More	0	26	5	26	0	260	0	260	0	260	0	260	0	260	0	260	0	0
												27	0	27	0	More	0	27	5	27	0	270	0	270	0	270	0	270	0	270	0	270	0	0
												28	0	28	0	More	0	28	5	28	0	280	0	280	0	280	0	280	0	280	0	280	0	0
												29	0	29	0	More	0	29	5	29	0	290	0	290	0	290	0	290	0	290	0	290	0	0
												30	0	30	0	More	0	30	5	30	0	300	0	300	0	300	0	300	0	300	0	300	0	0
More												More	U	More	U	More	0	More	U	More	0	350	0	350	0	350	0	350	0	350	0	350	0	1

REPORT DOCUMENTATION PAGE		Form Approved OMB No. 0704-0188	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22203-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.			
1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE October 1998	3. REPORT TYPE AND DATES COVERED Final; May - Nov. 1997	
4. TITLE AND SUBTITLE Practical Sequential Design Procedures for Submarine ASW Search Operational Testing: A Simulation Study		5. FUNDING NUMBERS DASW01-94-C-0054, OUSD(A) Task no. T-P9-773	
6. AUTHOR(s) Dr Steve Warner			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Institute for Defense Analyses 1801 N. Beauregard St. Alexandria, VA 22311		8. PERFORMING ORGANIZATION REPORT NUMBER IDA Document D-2060	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Director, Operational Test and Evaluation ATTN: CAPT Kennon Wilson, USN The Pentagon, Rm. 1C730 Washington, DC 20301		10. SPONSORING/MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES			
12a. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited. Directorate for Freedom of Information and Security Review, 14 December 1998.		12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words) The efficient design of a free-play, 24-hour-per-day, operational test (OT) of an ASW search system remains a challenge to the OT community. It will often be the case during an ASW search OT that artificial means of detecting the target are introduced in order to speed up the detection process. When used, these various artificial means of speeding up the detection process severely affect the realism of the search OT and limit the usefulness of the collected data. However, if these artificial procedures are not used, the OTD is faced with the problem of controlling the average length of time that a test event lasts. This presentation will identify test control rules that an OTD can employ from on-board the searching platform to allow for an efficient, realistic, free-play, 24-hour-per-day OT. The basic test control premise described here is to stop the test event if the time without a detection/classification grows too long. Furthermore, if this long period passes again without detection/classification, then the OTD uses a different search scenario in which the size of the area being searched is shrunk. This presentation will focus on the results obtained by simulating an ASW search OT in which test control rules were applied. The ramifications of the use of these various test control rules on the number of trials expected (for a given test duration), the test duration (for a given number of required trials), and on the quality of the estimates of search-related measures of effectiveness will also be discussed.			
14. SUBJECT TERMS Operational Test Design; Realistic Sonar Testing; Sequential Test Control Rules		15. NUMBER OF PAGES 150	
		16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT Unlimited